THE OHIO JOURNAL OF SCIENCE

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REPORT OF THE THIRTY-FOURTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

The Thirty-fourth Annual Meeting of The Ohio Academy of Science was held at the Ohio State University, Columbus, April 18 and 19, 1924, under the Presidency of Prof. Kirtley F. Mather. One hundred and fourteen members were registered as in attendance; fifty-nine new members were elected.

GENERAL PROGRAM.

FRIDAY, APRIL 18.

9:30 A. M.—Business Meeting.

10:30 A. M.—Reading of Papers in General Session.

2:00 P. M.—The Invitation Address by Dr. Albert P. Mathews, of the University of Cincinnati, on "How Shall We Measure the Quantity of Life?"

3:00 P. M.—Reading of Papers in Sectional Meetings.

6:30 P. M.—Annual Banquet, Ohio Union, followed by an address of welcome by Dean William McPherson, Ohio State University, with response by Dr. Edward L. Rice, Ohio Wesleyan University.

8:00 P. M.—Address by the President of the Academy, Prof. Kirtley F. Mather, Denison University, on "Geologic Factors in Organic Evolution," Campbell Hall Auditorium.

SATURDAY, APRIL 19.

9:00 A. M.—Adjourned Business Meeting.

10:30 A. M.—Reading of Papers in General Session and in Botany Section.

2:00 P. M.—Reading of Papers in Sectional Meetings and Demonstrations.

Minutes of Business Meetings.

The first business session was called to order by President Mather at 9:45 A. M. on Friday, April 18, 1924, and an adjourned session was held at 9:00 A. M. on the following day.

The President announced the appointment of the following committees for the meeting:

Committee on Membership—Dwight M. DeLong, Lewis H. Tiffany, Raymond J. Seymour, Harold E. Burtt, Frederick C. Blake.

Committee on Resolution—Albert P. Weiss, E. L. Moseley, Edgar N. Transeau.

Committee on Necrology.—Herbert Osborn,

The following *Auditing Committee* was elected by the Academy: Geo. D. Hubbard and H. C. Beardslee.

The following *Nominating Committee* was elected by the ballot of the Academy: Raymond C. Osburn, Lewis H. Tiffany, Geo. D. Hubbard, Raymond J. Seymour, Harold E. Burtt, Frederick C. Blake.

Report of the Secretary.

The following report by the Secretary was received and ordered filed.

Columbus, O., April 18, 1924.

To the Ohio Academy of Science:

The year now closing marks a change, as you know, in the Secretariate of the Academy and your Secretary has the distinct conviction that he would be untrue to the real feelings of the members of the Academy, certainly to his own, if he were to allow this fact to pass unnoticed, even if such a thing were possible. Of course all present miss from its accustomed place the genial face of the former Secretary, Dr. Edward L. Rice. During the eleven years of faithful service Dr. Rice not only made a real contribution to the Academy but made himself so useful, so helpful, not to say indispensable, that in the minds of many of us the names "Ohio Academy of Science" and "Edward L. Rice, Secretary" are almost synonymous. But words are unnecessary: "His works do praise him."

It is only fair to say, also, that the work of the former Secretary did not end with the election of his successor, since upon him fell the duty, for example, of clearing up the odds and ends after the Annual Meeting at Oberlin in March, of preparing the Annual Report for the printer, of notifying newly-elected officers, members and fellows, of sending out copies of resolutions passed at the last Annual Meeting, and of preparing a report of the meeting for *Science*, etc. It was therefore early in July before the complete and formal transfer of the archives was made

and even then the former Secretary was not entirely released, as we have freely availed ourselves of his generous offer to lend assistance at any time and in any way possible.

Furthermore it should be stated that *the Secretariate was turned over in an excellent, up-to-date condition.*

The first item of more than routine importance to claim the attention of the new Secretary was the publication in pamphlet form of a memoir of the late Emerson McMillin, referred to on page 281 of the Proceedings of the Thirty-third Annual Meeting. Some 50 copies of this memoir were published by the Academy and distributed to the family and selected friends of Mr. McMillin.

The next item of general interest to the Academy was an invitation from the Ohio Forestry Association, through its Secretary, Prof. Edmund Secrest, inviting the members of the Academy to participate, as guests of the Association, in a field meeting at the John Bryan Park on September 21 and 22, 1923. This invitation was passed on to the members of the Academy in a letter dated September 8, 1923. Several members of the Academy availed themselves of this very courteous invitation, much to their pleasure and delight, and one or two of our members appeared on the program put on by the Association.

Owing to the sudden and unexpected passing away of our most distinguished member, the late Dr. T. C. Mendenhall, on March 22, 1924, the Secretary assumed the authority to call Dr. E. L. Rice over the long distance telephone and request him to represent the Academy at the funeral services held at Ravenna. This he consented to do and did. This action has since been approved by the Executive Committee.

The routine work of the office has been about as usual and very considerable; details have been taken care of as promptly and as efficiently as possible under the circumstances.

The generous, helpful cooperation of all the officers of the Academy has been a source of real inspiration throughout the year, for which hearty thanks are due and hereby recorded.

WILLIAM H. ALEXANDER, *Secretary.*

Report of the Treasurer for the Year 1923-1924.

The following report by the Treasurer was received and referred to the Auditing Committee whose report is appended.

To the Ohio Academy of Science:

The Treasurer submits the following report for the period from March 26, 1923, to April 2, 1924:

RECEIPTS.

Cash balance on hand March 26, 1923	$766.05
Librarian's sales of publications	37.97
Interest on certificate of deposit	19.50
Members dues, paid through the A. A. A. S. and directly to the Treasurer	709.14
Total receipts	$1,532.66

DISBURSEMENTS.

American Association for the Advancement of Science	$ 76.00	
Columbian Building and Loan Association, for deposit	750.00	
H. C. Cowles, traveling expenses	30.00	
E. L. Rice, secretarial and traveling expenses	10.78	
Earl Sheffel, refund	2.00	
Independent Print Shop	29.00	
Spahr & Glenn, Printers	3.25	
A. E. Kraus, Print Shop	32.00	
Herbert Osborn, traveling expenses	13.50	
Wm. Alexander, secretarial expenses	18.15	
Eunice McCray, stenographic service	10.00	
Helen M. Coleman, stenographic service	3.25	
Total Disbursements		$ 977.93
Cash balance on hand April 2nd, 1924		554.73
Assets—Certificate of deposit for		650.00
Total Assets		$1,204.73

The original purchase of a certificate of deposit for $750.00 was later reduced $100.00 to pay the honorarium to the Academy Secretary. It will be noted that this item does not appear above. Cancelled checks and vouchers are herewith submitted with the books.

Dr. Burton E. Livingston, Permanent Secretary of the A. A. A. S., reported that the plan of having joint dues in the Academy and the A. A. A. S. payable through his office was working satisfactorily.

Respectfully submitted,

A. E. Waller, *Treasurer.*

Books, checks and vouchers submitted and found to be correct.

Geo. D. Hubbard,
H. C. Beardslee,
Auditing Committee.

Report of the Executive Committee.

The following report of the Executive Committee was received and ordered filed.

Columbus, O., April 18, 1924.

To the Ohio Academy of Science:

A meeting of the Executive Committee was held in Columbus on November 9, 1923, with all members present except the President, who because of absence from the State could not attend the meeting. By invitation Vice-President Barrows and Prof. Raymond C. Osburn were present, the former presiding over the meeting.

A letter was read from President Mather, extending greetings and good wishes and suggesting among other things that some action should be taken regarding the expenses of Prof. Herbert Osborn as the duly accredited representative of the Academy to the Leidy Commemorative Meeting to be held in Philadelphia on December 6, 1923. Thereupon the committee instructed the Treasurer to reimburse Professor Osborn for all necessary expenses incurred in this connection.

The Secretary was requested and authorized to make such arrangements as might seem wise in the establishing of temporary headquarters for the visiting members of the Ohio Academy at the annual meeting of of the American Association for the Advancement of Science to be held in Cincinnati the latter part of December, 1923. This action was very satisfactorily carried out through the generous cooperation of members of the Academy living in Cincinnati.

At this meeting of the committee it was decided to accept the invitation of the Ohio State University to hold the Thirty-fourth Annual Meeting of the Academy at that institution. It was also agreed that the time should be "very near Easter" but the exact date was left for the Secretary to determine after some further investigations.

A second meeting of the Executive Committee was held in Columbus at the office of the Secretary last evening with all members present.

At this meeting forty applications for membership in the Academy were approved subject to final ratification by the Academy.

The Secretary placed before the committee a cordial invitation from the Faculty of the College of Wooster, heartily seconded by the staff of the Ohio Agricultural Experiment Station, to hold the next Annual Meeting of the Academy at Wooster. The committee decided to refer the invitation to the Academy for such action as it may see fit to take.

The following letter from Dr. Burton E. Livingston, Permanent Secretary, American Association for the Advancement of Science, written in reply to a letter inviting Dr. Livingston or some other officer of the A. A. A. S. to be present at the Annual Meeting of this Academy, was laid before the committee, viz.:

WASHINGTON, D. C., March 18, 1924.

DEAR MR. ALEXANDER:—I have your letter of March 10 and have read it with much interest. It is the plan of the American Association to have, whenever possible, a representative of the Association in attendance at each annual meeting of the affiliated academies. This was decided at the Cincinnati meeting. But the whole question of the arrangements with affiliated academies has recently come up again for discussion and we think it will be best not to begin naming official representatives for academy meetings till the Executive Committee has had opportunity to define the attitude of the Association in regard to affiliated academies in a manner clearer than has thus far been done. We are making a serious study of the whole problem of academy affiliation and it may be possible that some improvements can be introduced. When we do begin to send representatives to the academy meetings, those representatives should naturally have the whole matter clearly in mind, and that could not be the case at present. There will doubtless be important matters to be discussed with the several academies.

I hope you will understand from this why I feel that we should postpone till a later time our beginning to name official representatives for the academy meetings.

I should like nothing better than to come to your meeting myself and I hope to be able to do so next year, perhaps.

Thanking you, and with all good wishes for the great success of your meeting,

Yours very sincerely,

BURTON E. LIVINGSTON,
Permanent Secretary.

The following communication was received from Charles E. Deam, President of the Indiana Academy of Science, and referred to the Academy for action, viz.:

BLUFFTON, IND., April 9, 1924.

DEAR MR. ALEXANDER:—I am sorry I shall not be able to attend the meeting of the Ohio Academy of Science April 18 and 19.

I wish if you do so, you would extend a most cordial invitation to all members of the Ohio Academy of Science to meet with the Indiana Academy of Science at their spring meeting to be held at Marengo, Ind., May 15–17.

At this meeting those who wish may go through the Marengo Cave at Marengo, and on the second day may go through Wyandotte Cave, about 13 miles distant. The field trips will be very interesting to the botanist and the geologist. The leader of the botanical section is well acquainted with the area and will show such rare plants as Isoetes Engelmanii, Smilax Bona-nox, and many others that are extremely local. The geologists will be led by one who has walked the entire region and is well acquainted with it. Come in hiking clothes.

Yours most cordially,

CHAS. C. DEAM.

An invitation was read from the President and Secretary of The Franklin Institute, Philadelphia, Pa., to participate in the celebration on September 17, 1924, of the *Centenary* of the signing of the Act of Incorporation of the Institute, by the appointment of a representative; this invitation is also referred to the Academy for action.

An invitation was also read from the British Association for the Advancement of Science, inviting members of this Academy to attend its Annual Meeting to be held in Toronto from August 6 to 13, 1924. Your Executive Committee suggests the names of Dr. A. E. Waller and Dr. Edward L. Rice as delegates to this meeting.

Respectfully submitted,

WILLIAM H. ALEXANDER,
For the Committee.

Report of the Publication Committee.

The following report of the Publication Committee was received and ordered filed:

The Annual Report of the Thirty-third Meeting, Proceedings, Vol. VII, Part 8, contained 29 pages and was published November 26, 1923. The report minus the membership list was also published in the *Ohio Journal of Science: 23:* 209–234, 1923.

Respectfully submitted,

H. C. SAMPSON, *Chairman.*

Report of the Library Committee.

The following report of the Library Committee was received and ordered filed:

COLUMBUS, O., April 18, 1924.

To the Ohio Academy of Science:

The Library Committee begs to report that all duties devolving upon it have been discharged as promptly as possible.

The sale of publications during the year amounted to $37.97. This amount has been turned over to the Treasurer of the Academy.

The Proceedings of the Thirty-third Annual Meeting, 1923, were received from the printer in December and copies were mailed to all members of the Academy and to the exchanges early in the year 1924.

The publications received by the Academy on exchange have been added to the sets filed in the University Library. The scientific sections of the library have been increased annually by the purchase of many important sets and the hope is expressed that more and more the University Library will serve as the center of scholarly research by members of the Academy.

Respectfully submitted,

C. W. REEDER,

For the Library Committee.

Report of the Trustees of the Research Fund.

The Trustees reported, orally, that owing to the very recent death of their Chairman, Dr. T. C. Mendenhall, who had full charge of the books and records pertaining to the work of the Board of Trustees and usually prepared the report, it had been impossible for the other members to prepare a written report in time for this meeting, or to work out the details of the plan recommended by Dr. Mendenhall and endorsed by the Academy at the last Annual Meeting (see page 282, Proceedings, Thirty-third Annual Meeting) regarding the investment of the Research Fund and the use of the income therefrom. The Board requested another year in which to prepare a report. The request was granted.

A preliminary examination of the bank accounts, made soon after the April, 1924, meeting of the Academy, shows the following: Bills to the amount of $126.36 were paid subsequent to April 1, 1923, and additions from interest on bonds amounting to $27.62 have been credited, leaving a cash balance of $724.82, or a total resource with bonds of $1,324.82.)

In this connection the Secretary read the following letter written by Dr. Mendenhall only three days before his death:

RAVENNA, O., March 19, 1924.

MY DEAR MR. ALEXANDER:

Yours of the 17th has reached me together with another communication from you of an earlier date, which I found awaiting me on my arrival from Columbus on last Saturday night. You are perhaps by this time aware that I have been in the City of Columbus for the last two weeks, the victim of the ingenuity and indefatigable zeal of the doctors,

who have been doing everything that they can for me, or rather, I should say to me and eventually for me.

However, the investigation with all that has gone along with it has fatigued me very much and I was glad to reach home Saturday night. Now this has been a painful and possibly serious affair with me, and therefore, you will see that I must at once abandon all attempts to do anything for the Academy of Science for some time to come.

I regret this very much as there are several things which should be looked after in regard to the Emerson McMillin Fund. Not one single transaction has taken place so the financial situation is precisely as I have reported plus, of course, the income from our invested funds, so it will be very easy to determine approximately what amount will be available on the 19th of April. I hope to be able to prepare something in the form of a report by that time.

Yours faithfully,

T. C. MENDENHALL.

Upon motion duly made and carried, the Trustees were instructed to conserve the income from the McMillin Fund during the ensuing year.

Report of the Committee on State Parks and Conservation.

The Chairman of the Committee, Prof. Herbert Osborn, stated that the committee had not succeeded in having any formal meetings as it is made up, very properly, of members scattered through the State and there had been no convenient occasion on which to get the members together. It is of interest to report, however, that there has been distinct progress in the matter of reservations for park, game refuge and forestry purposes which have materially extended the areas devoted to these purposes and which we may count as distinct advances. The Bryan State Park which includes part of the Clifton Gorge and which was mentioned in our last report as likely to be finally accepted by the State has now definitely become State property and is administered by the State Experiment Station, so that it may be counted as permanently devoted to park and reservation purposes and its scenic, biologic and geologic features preserved for future students.

At a meeting of the State Forestry Society last September, to which our members were invited, as pointed out in the Secretary's Report, we had an opportunity to observe the conditions and possibilities there under very favorable circumstances.

The Roosevelt Game Refuge, now embracing some 15,000 acres, was dedicated last fall and is already proving its value in stimulating interest and activity in the preservation of the native plants and animals of the region. Additional tracts have been secured for the state forests and these have distinct value as areas in which conditions will serve to perpetuate our native fauna and flora. The park system of Cleveland, which was visited with the kind guidance of Professor Fullmer, gives very encouraging evidence of a broad plan for the development of adequate park areas including some remarkably fine natural scenery and the preservation of natural conditions for plant and animal life.

The publication of the Naturalists Guide by the Ecological Society of America and for which the Ohio areas have been very carefully listed by Dr. E. Lucy Braun, is expected in the near future and will make available to our members a detailed list of tracts now reserved or which should be made into reservations when possible. There is a manifest interest in this subject in many of the states and great progress has been made in some of our sister states, notably New York and Iowa, and we may expect a growing appreciation of its importance and efforts of the Academy should be continued in order that the scientific aspects may receive proper attention.

This statement by the chairman of the committee was received as a report of progress and the committee continued.

Report of the Committee on Legislation.

The chairman of the Committee made an oral statement to the effect that in as much as the General Assembly failed to pass the bill (H. B. No. 400) that was before it at the time of our last meeting and as there has been no session of the Assembly since that time, the committee has not been able to do anything more than "watchful waiting." This statement was received as a report of progress and the committee continued.

Election of Officers.

The following officers and committee members for 1924–25 were elected by the ballot of the Academy.

President—Prof. Edgar N. Transeau, Ohio State University, Columbus.

Vice-Presidents:
Zoology—Ralph V. Bangham, Wooster College, Wooster.
Botany—Prof. Edmund Secrest, Ohio Agricultural Experiment Station, Wooster.
Geology—Prof. G. W. Conrey, Ohio State University, Columbus.
Medical Sciences—Prof. R. G. Hoskins, Ohio State University, Columbus.
Psychology—Prof. F. C. Dockeray, Ohio Wesylean University, Delaware.
Physical Sciences—Prof. C. D. Coons, Denison University, Granville.

Secretary—William H. Alexander, U. S. Weather Bureau, Columbus.

Treasurer—Dr. A. E. Waller, Ohio State University, Columbus.

Elective Members of the Executive Committee—Prof. C. G. Shatzer, Springfield; Prof. Bradley M. Patten, Cleveland.

Member Publication Committee—Prof. Lewis G. Westgate, Delaware.

Trustee Research Fund—Dr. Edward L. Rice, Ohio Wesleyan University, Delaware.

Member of Library Committee—Prof. Frederick C. Blake, Ohio State University, Columbus.

Legislative Committee—Wm. H. Alexander, Columbus; M. M. Metcalf, Oberlin; Paul M. Rea, Cleveland; Edward L. Rice, Delaware; L. B. Walton, Gambier.

Representatives on Editorial Board of Ohio Journal of Science:
Zoology—Prof. R. A. Budington, Oberlin College, Oberlin.
Botany—Prof. Bruce Fink, Miami University, Oxford.
Geology—Prof. G. D. Hubbard, Oberlin College, Oberlin.
Medical Sciences—Prof. F. C. Waite, Western Reserve University, Cleveland.
Psychology—Prof. H. A. Aikins, Western Reserve University, Cleveland.
Physical Sciences—Prof. S. J. M. Allen, University of Cincinnati, Cincinnati.

Election of Members.

The following persons were regularly nominated and elected to membership in the Academy:

Alderman, Ovid A.; Botany, Zoology; 308 Bowman St., Wooster.
Bartholomew, Paul S.; Botany, Entomology, Ornithology; R. F. D. No. 3, Sycamore.
Bearss, Esther; Biology; Cochran Hall, Westerville.
Beaver, William C.; Zoology, Medical Sciences, Botany; Head of Department of Biology, Wittenberg College, Springfield.
Bilsing, S. W.; Entomology, Zoology; College Station, Texas.
Busch, K. G. A.; Chemistry, Botany; Capital University, Columbus.
Camp, Wendell H., Geology, Zoology; Otterbein College, Box 101, Westerville.

Caskey, Marion W.; Zoology; Ohio State University, Columbus.
Conger, Allen C.; Zoology; Darlington Road, Delaware.
Dehus, Delores; Biology; 714 S. Main St., Ada.
Dickerson, Bessie; Zoology, Medical Sciences; New Concord.
Dietz, David; Astronomy, Physics; The Cleveland Press, Cleveland.
Edwards, Linden Forest; Zoology; Reynoldsburg.
Gambrell, Foster Lee; Entomology, Zoology; Ohio State University, Columbus.
Gillespie, J. S.; Geology; 1075 Madison Ave., Columbus.
Goodwin, Howard R.; Archaeology; Ohio State Archaeological and Historical Museum, Columbus.
Gourley, J. H.; Horticulture; Wooster.
Hall, Schuler P.; Physics; Wooster College; Wooster.
Harp, Hugh G.; Astronomy, Meteorology; Wittenberg College; Springfield.
Heath, A. B.; Physical Geography, Meteorology, Geology; 544 Franklin St., Hamilton.
Hefner, Robert A.; Zoology, Astronomy; 238 W. Tenth Ave., Collmbus.
Henderson, A. Lee; Psychology, Medical Sciences; 489 Maynard Ave., Columbus.
Hilker, H. V.; Geology, Archaeology; 325 N. Third St., Hamilton.
Johnson, H. M.; Psychology; Ohio State University; Columbus
Jones, Merlin Perry; Entomology, Botany; 89 Euclid Ave., Columbus.
Kao, Chung Kwai; Botany; 101 W. Eighth Ave., Columbus (Permanent address: Hoking, Yunnan, China).
LaFleur, Albert; Geography, Geology, Meteorology, History; Box 357, Athens.
Lamborn, R. E.; Geology; Department of Geology, O. S. U.; Columbus.
Lewis, George; Electro and Radio Physics; Crosley Radio Corporation, Cincinnati.
Lindsey, A. W.; Entomology, Zoology; Denison University, Granville.
Lusk, Ralph G.; Geology; Granville.
Mason, Capt. Paul; Archaeology, Meteorology, Public Health; 271 S. Champion Ave., Columbus.
Martin, Clare; Chemistry, Physics; State Normal College, Bowling Green.
Mathews, Albert P.; Biochemistry, Physiology; University of Cincinnati; 255 Loraine Ave., Cincinnati.
Miller, David F.; Zoology; 1466½ Pennsylvania Ave., Columbus.
Moon, M'Della; Botany, Zoology; 48 Seventeenth Ave., Columbus.
Moses, C. F.; Geology; Muskingum College; New Concord.
Olson, Henry W.; Zoology; 356 Centner Ave., Columbus.
Orr, Grover L.; Chemistry, Physics; Capital University, 767 College Ave., Columbus.
Pallister, John C.; Entomology, Zoology; Cleveland Museum of Natural History, 2717 Euclid Ave., Cleveland.

PATTERSON, EDNA; Zoology, Entomology, Botany, Astronomy; 130 W. Tenth Ave., Columbus.
PETERSON, CHARLES J.; Botany, Horticulture; Peterson Nurseries Co., Wilmington.
POLLITZ, Louise C.; Geology, Geography, Ecology; Cleveland Museum of Natural History, Cleveland.
REEVES, PRENTICE; Psychology, Medical Sciences; 208 N. Sandusky St., Delaware.
RICKEY, EDNA; Psychology, Medical Sciences; 53 Smith Place, Columbus.
ROFKAR, WILLIAM F.; Zoology, Botany, Geology; 504 Beall Ave., Wooster.
SCHRADIECK, HENRY E.; Ichthyology, Fish Culture; Urbana University, Urbana.
TILFORD, PAUL E.; Botany, Chemistry; Ohio Agricultural Experiment Station, Wooster.
TUTTLE, W. W.; Physiology, Psychology; Bremen.
VER STEEG, CARL; Geology, Geography; 324 Nold Ave., Wooster.
WARTERS, MARY; Zoology, Entomology, Botany, Chemistry, Anatomy; 130 W. Ninth Ave., Columbus.
WEATHERBY, BENJAMIN B.; Physics; Toledo University, Toledo.
WELTON, F. A.; Agronomy; Ohio Agricultural Experiment Station, Wooster.
WHITE, GEO. W.; Geology; 86 E. Lincoln St., Westerville.
WILSON, IRA T.; Zoology; Heidelberg University, Tiffin.
YEE, MARTIN A.; Medical Sciences, Biology; University of the City of Toledo, Toledo.
YOUNG, H. C.; Botany; Ohio Agricultural Experiment Station; Wooster.
ZINKE, STANLEY G.; Meteroology, Ecology, Medical Sciences; 1814 Vine St., Cincinnati.
ZINZON, W. A.; Physics; New Concord.

Report of the Committee on Election of Fellows:

The following report of the Committee on Election of Fellows was accepted and ordered filed:

COLUMBUS, O., April 18, 1924.

To the Ohio Academy of Science:

A meeting of the Committee on the Election of Fellows was held last evening in Columbus at the office of the Secretary. Eight members of the committee were present, one was represented by proxy, and two were absent without representation.

Of the candidates considered, fourteen received the necessary nine favorable votes and were declared elected. The fellows elected will be personally notified, and the list will be published in the Proceedings.

Respectfully submitted,

WILLIAM H. ALEXANDER, *Secertary.*
For the Committee.

The following is a list of those elected to fellowship:

Ralph V. Bangham	Lawrence L. Huber
John W. Baringer	Thomas G. Phillips
Samuel Wood Chase	Edmund Secrest
Guy W. Conrey	Ernest Rice Smith
Floyd Carlton Dockeray	Paris B. Stockdale
H. A. Gossard	Herbert Anderson Toops
Roy Graham Hoskins	Charles J. Willard

Resolutions.

The following resolutions were unanimously adopted by the Academy:

1. The Academy wishes to thank the members of the Local Committee and the officers of the Ohio State University for the efforts they have made and the courtesies they have extended toward making the Thirty-Fourth Annual Meeting of the Ohio Academy of Science a success.

2. The Academy wishes to express to Dr. Albert P. Mathews, Professor of Biochemistry at the University of Cincinnati, its appreciation of the special lecture on "How Shall We Measure the Quantity of Life?"

3. The Academy wishes to express its endorsement of the resolutions submitted to the United States Congress by the American Ecological Society, to set aside the Glacier Bay region as a National Monument.

Report of the Committee on Necrology.

The following report of the Committee on Necrology was adopted by the Academy and ordered filed:

Memorial to Dr. Thomas Corwin Mendenhall.

The Ohio Academy of Science mourns today a trusted leader and former president, Thomas Corwin Mendenhall. He was eminent in Physical Science as an investigator, a teacher, an expositor and an organizer. The Franklin Institute of Philadelphia in granting to him in 1918 the Franklin medal, "founded for the recognition of those workers in physical science, * * * * * whose efforts have done most to advance a knowledge of physical science" made their award "in recognition of his fruitful and indefatigable labors in phsycial research, particularly his contribution to our knowledge of physical constants and electrical standards." This was one of a long series of similar awards, crowning his fifty years of leadership in Science.

Born at Hanoverton, Ohio, October 4, 1841, and living till March 22, 1924, his life covered one of the most eventful periods of human history and his scientific career was coincident with many of the most striking developments of modern science.

His earliest scientific paper was published in 1870. For the succeeding thirty years his contributions to the leading scientific periodicals were frequent and important. The Proceedings of the A. A. A. S., the American Journal of Science, Popular Science Monthly, Science, and the U. S. Coast and Geodetic Servey, were principal avenues of publication.

As the first professor of physics of the Ohio State University, the pioneer work of equipping and putting into service a laboratory for instruction and research fell to him. He began this work in 1873, the first man elected to the faculty of the newly organized institution.

In 1878 he accepted the task of organizing the Physics department of the Imperial Universtiy of Japan at Tokio. He also founded the meteorological observatory there. His research work in Japan included careful measurements of the gravitation constant at Tokio and on the summit of Fujiyama, a determination of the density of the earth and some very accurate work with a Rutherford grating on the lines of the sun's spectrum. The celebrated astronomer, Professor Young of Princeton, pronounced these results as extraordinary. He also helped found the Seismological Society of Japan, which has done more than any other organization to make seismology an exact science.

In 1881 he returned to this country and resumed his work at Ohio State University. In the following year he organized the Ohio State Weather Service. His activity in seismology continued after his return.

In 1884 he became professor in the U. S. Signal Corps at Washington and developed instruments for the study of earthquakes. He also started C. F. Marvin, a former student of his in Ohio and the present distinguished Head of the U. S. Weather Bureau, in this same line of work. Dr. Mendenhall also began at this time an elaborate study of atmospheric electricity.

In 1886 he became president of the Rose Polytechnic Institute. Though a capable administrator he somehow kept up his scientific investigations and published four or five scientific papers during his three years presidency. The National Academy of Sciences also published a large volume on his work during this period in atmospheric electricity.

In 1889 he was made Superintendent of the U. S. Geodetic Survey. He here developed the famous "Mendenhall half-second pendulum," which for more than 25 years continued to do extraordinarily accurate work in fifteen Survey stations, and is still relied upon for the most exact results. One of these instruments was carried to Alaska, repeatedly landed in a surf boat for observations and when brought back to Washington gave the same value for "g" that it had given before the journey, to one part in 5,000,000. The reports and bulletins of the Survey contain many of his papers between 1889 and 1894. He was also made Superintendent of Weights and Measures and achieved the important task of putting our national system of weights and measures upon a Metric basis.

In 1893 he was one of five eminent electricians (chosen by mail ballot of 150 leading electrical men) to represent the United States at the International Electrical Congress at Chicago. Differences of opinion

developed there threatened to make agreement upon definitions of the principal electrical units impossible. The Franklin Institute now exhibits a sheet of paper on which Dr. Mendenhall one evening wrote down definitions of the ampere, the volt and the ohm. These he presented next morning to the Chamber of delegates; and the definitions finally adopted are practically identical with his penciled memorandum.

In 1894 he began a seven year service as president of the Worcester Polytechnic Institute.

His work as an investigator and as an organizer of research was indeed notable, but he also had a most unusual gift for making the results of scientific work intelligible and interesting to popular audiences. As a consequence he has been for many years repeatedly called upon for memorial and dedicatory addresses. In 1892 he gave a Convocation Address at Johns Hopkins on "Measurements of Precision, considered in Their Relation to the Condition of Man," and the same year prepared the principal address for the dedication of the new Ryerson Laboratory of the University of Chicago. He gave two series of lectures at the famous Lowell Institute in Boston, one in 1882 and one in 1892. Also lectures at Cooper Union, New York and in Philadelphia, Baltimore and Washington. In 1887 he was made a member of the National Academy of Sciences. In 1888 he was president of the American Association for the Advancement of Science and won golden opinions as presiding officer of the Toronto Meeting. The next year he gave the retiring presidential address at Indianapolis. In 1894 he gave an address as retiring president of the Philosophical Society of Washington. Many of us here remember the delightful address he gave a few years ago as president of our own Ohio Academy of Science and his address on "Some Metrological Memories" before the Franklin Institute in 1918.

His work has been recognized by the award of numerous decorations and medals. From the Paris Exposition in 1900 he received a medal for a monograph entitled "Scientific, Technical and Engineering Education in the United States," from the Imperial Education Society of Japan in 1911 a gold medal. The same year he was decorated with the Order of Sacred Treasures, Japan. The receipt of the gold medal of the Franklin Institute has already been mentioned.

These are but a few of the high points of achievement in a notable career in physical science.

Mention has already been made of his pioneer work in equipping and developing the physical laboratory of the Ohio State University and this is but a small part of his service to that institution. His wise selection of equipment is shown in the fact that many of his early purchases are still giving good service on lecture table and in laboratory. His inspiring leadership of many of the early graduates, such as C. F. Marvin, W. C. Sabine, C. F. Scott, gave them a real start in their notable scientific careers.

Professor Derby, one of his confreres on the faculty in the 80's, has written concerning his important part in determining the educational policy of the institution as follows: "In every faculty certain members are conceded leadership. It soon became plain to me that in questions of

common University concern we usually followed Dr. Mendenhall. In the field of our educational policy he exercised a directive mind. Other professors keen and able in their several subjects, were less attentive to the interests of the institution as a whole, or too individualistic to secure agreement with their suggestions. We were fully awake to the trend of various propositions brought before us and our discussions, though usually courteous, were earnest and now and then sharp in tone. A determination that the work of the institution should be exacting and of high quality was always evident, and any suspected failure to maintain that quality occasioned sharp criticism. In the maintenance of these high standards. Dr. Mendenhall was foremost and his pungent wit seldom missed its mark. When later he withdrew from the University to enter a different scientific field his former colleagues deplored the loss of a beloved comrade, notable scientist and leader in education, but followed his brilliant career with affectionate admiration."

For many years following 1901 a break in health forced him to retire from active scientific and educational work. It was with great satisfaction therefore that some of us heard in June, 1919, that the Governor had appointed him to be a Trustee of the Ohio State University, on the first faculty of which he had served so efficiently many years before. His wise leadership soon caused his election as Chairman of the Board, a position which he greatly honored. His interest in the University never lagged and his faith in its future was evidenced in many ways. One of his last acts was to sign the diplomas for the graduates of the winter quarter of 1924.

In the year 1920, on the occasion of the celebration of the fiftieth anniversary of the founding of the University, Dr. Mendenhall gave to the University a sum of money for the endowment of a gold medal to be known as the Joseph Sullivant Medal. This medal is to be awarded at five year intervals to "that son or daughter of the University who shall have done or have completed, within the five-year period since the last award, a really notable piece of work in either the Liberal, the Fine, or the Mechanic Arts, the pure or applied Sciences, including the various branches of Engineering." The first award was made in 1923 to Mr. Benjamin Garver Lamme, of the Class of 1888.

Dr. Mendenhall's active connection with our Ohio Academy of Sciences began shortly after his return to Ohio in 1912 and he has been a devoted and helpful member interested in promoting its every interest. Almost as soon as he had acquired membership he was elected President, a quite unusual proceeding. This occurred at the Oberlin meeting, 1913, and he served for the year 1914 with such skill and enthusiasm as to give us all renewed courage and confidence in the mission of the Academy.

As Trustee and for a number of years Chairman of the Research Fund of the Academy, serving from 1916 to his death, he was greatly interested in the use of the Academy funds for research and used rare discrimination in the assignment of its limited income to secure the largest benefits in the encouragement of research.

He was particularly interested in the securing of larger support for the Academy and served most faithfully on the legislative committee

which sought state support for Academy activities, especially for publication of the results of scientific studies. He expressed the hope and it was one of his cherished projects that the Academy might sometime be provided with a suitable building for its permanent home and as a center of its activities and that it might serve in some very vital way for the promotion of the scientific functions of the state. His recommendations and suggestions are matters of recent record and may well serve us in our future efforts for the development of scientific activities in the state.

With all these relations the thing that we feel most deeply today is the friendly nature of his work among us. With a most unusual experience in scientific development of more than a half century, a remarkable acquaintance with scientific work and workers he possessed such a broad appreciation of the work and accomplishment of others and such a friendly attitude toward even the most humble worker in the field of science that his presence and interest were a constant source of encouragement. With a multitude of honors and distinctions he was still one of the most democratic and unassuming of men. With a wealth of achievement, seldom equalled, to his credit he was ever modest in reference to the importance of his own contributions to science. He was a man whom we could admire and love, whose friendly greeting will be missed but whose memory will be cherished as representing the finest spirit of scientific devotion, achievement and fellowship. We have recorded our esteem and appreciation of his worth in such honors as it was in our power to give. We have now to place on record, as our lasting recognition of his leadership, this declaration of our high regard for his service, our great indebtedness for his many activities in the Academy and our tribute to his memory as a friend and fellow worker. His fine accomplishments and inspiring personality will long remain with us as a beautiful memory.

Herbert Osborn. *Chairman,*
A. D. Cole,
Wm. McPherson,
Committee on Necrology.

Meeting Place, 1925.

President Mather laid before the Academy the invitation from Wooster College to meet in Wooster next year. Mr. W. C. Devereaux stated that he was fully prepared and authorized to extend an invitation to the Academy to meet in Cincinnati next year but inasmuch as Wooster seemed to have a superior claim in that the Academy had never met in that city, he would withhold his invitation until some future time in favor of Wooster. Whereupon the Academy by vote declared itself in favor of accepting the invitation from Wooster College but left the final decision as to the next meeting place in the hands of the Executive Committee.

Change in Name of Section.

Upon motion of Mr. W. C. Devereaux, seconded by Prof. F. C. Blake, the Academy approved the changing of the name of the section heretofore known as *The Section of Physics* to that of *The Section of Physical Sciences.*

At the suggestion of Dr. E. L. Rice it was unanimously agreed that the passing of this motion would serve also as notice of such changes in the Constitution and By-Laws as might be necessary to conform to said motion.

Delegates to the Toronto Meeting of the B. A. A. S.

By motion duly made and seconded the Academy unanimously approved the recommendation of the Executive Committee that Dr. A. E. Waller and Dr. Edward L. Rice be designated as the duly accredited delegates of this Academy to the Annual Meeting of the British Association for the Advancement of Science to be held in Toronto, August 6–13, 1924.

Scientific Sessions.

The following is the complete scientific program of the meeting:

PRESIDENTIAL ADDRESS.

Geologic factors in social evolution.....KIRTLEY F. MATHER

PUBLIC LECTURE.

How shall we measure the quantity of life?.....ALBERT P. MATHEWS

PAPERS.

1. Laboratory exercises in atomic structure. (15 min.), WM. LLOYD EVANS AND JESSE E. DAY
2. The valley of ten thousand smokes in 1923. (20 min., lantern), KIRTLEY F. MATHER
3. Tantalum: The newest metal contributed by science to industry. (30 min.), JAMES R. WITHROW
4. Recent work in endocrinology. (30 min., lantern).....R. G. HOSKINS
5. The weather. (15 min.).....W. C. DEVEREAUX
6. Pressure and life. (15 min.).....STANLEY G. ZINKE
7. Glare: With demonstrations. (30 min.).....F. C. CALDWELL
8. Medical education in Colonial America. (15 min.).....F. C. WAITE
9. The relation of fish production to forestation. (10 min.), RAYMOND C. OSBURN
10. The application of radio in distance determination. (20 min.), GEORGE LEWIS
11. A hydrogen sulfide delivery system. (7 min.).....JESSE E. DAY
12. Respiration in the orthoptera. (15 min.).....M. O. LEE
13. The nutrition of Euglena gracilis. (10 min.).....W. J. KOSTIR
14. Pest hunts in Wood County. (10 min.).....E. L. MOSELEY

15. The development of the intestinal coiling of the minnow (Campostoma anomalum). (10 min., lantern).....W. C. Kraatz
16. Morphology of gigantorhynchus (ancanthocephala). (10 min.), M. W. Caskey
17. The periodical cicada in Ohio. (20 min., lantern).....H. A. Gossard
18. An Ohio record for the dragonfly (Tachopteryx thoreyi). (5 min.), James S. Hine
19. Parasites of the black bass. (10 min.).....R. V. Bangham
20. Habits of the common water snake, particularly in its relation to fish. (5 min.).....F. A. Hanawalt
21. New terms suggested to designate the various modes of nutrition in organisms. (5 min.).....W. J. Kostir
22. Recent mammal records in Ohio. (5 min.).....James S. Hine
23. Ecologic notes on some homoptera of the southwest. (10 min., lantern), Herbert Osborn
24. The early differentiation of the longitudinal zones in the neural plate of rana. (10 min.).....R. A. Knouff
25. Two new hereditary tumors in drosophila. (15 min.).....Ira T. Wilson
26. The primitive lines in amblystoma. (15 min.).....F. L. Landacre
27. Comparisons of protozoan nuclei. (20 min.).....Maynard M. Metcalf
28. A study of comparable developmental stages in chick and pig embryos. (10 min.).....B. M. Patten
29. The differentiation of the epichordal and prechordal portions of the brain in amblystoma. (10 min.).....R. C. Baker
30. The spherical blackboard in the teaching of embryology. (5 min.), Edward L. Rice
31. The effect on basal metabolism of ingested adrenalin chloride. (15 min.), Fred A. Hitchcock
32. Heredity defects of the human hands, with special reference to symphalangism. (15 min.).....R. A. Hefner
33. A novel type of symphalangism (?) or hypodactyly (?). (10 min.), O. L. Inman
34. Some practical and theoretical aspects of lubricating oil emulsions as a scalecide. (10 min.).....L. L. Huber
35. Interaction of the genes in the production of eye color in drosophila. (10 min.).....W. P. Spencer
36. The development of forestry practice. (25 min., lantern), Edmund Secrest
37. Botany: Opportunity. (15 min.).....Maximilian Braam
38. Present tendencies in high school biological courses. (10 min.), William E. Niehaus
39. Some Ohio inter morainal lakes and lake beds. (10 min., lantern), George D. Hubbard
40. The age of the glacial drift in Licking County, Ohio. (10 min.), Ralph G. Lusk
41. Some glacial pebbles and cobbles found beyond the glacial boundary in Muskingum and Guernsey counties. (10 min.).....C. F. Moses
42. The composition of the Illinoian drift in Clermont County, Ohio. (5 min.), G. W. Conrey
43. Drainage changes in the Warren-Youngstown-Sharon-New Castle areas. (20 min.).....G. F. Lamb
44. Erosion levels in the Colorado Plateau. (15 min.).....Robert F. Webb
45. Differences in the form of species usually regarded as common to North America and Europe. (15 min.).....August F. Foerste
46. Plant life in ordovician and silurian times. (10 min.).....August F. Foerste
47. The positions occupied by orthoceroids while alive. (10 min.), August F. Foerste
48. An amphibian trail from Pottsville formation. (5 min.).....G. F. Lamb
49. The Cleveland shale fishes of northern Ohio. (25 min., lantern).....J. E. Hyde
50. Two recent papers on the earth's interior. (15 min.).....Walter H. Bucher

51. The importance of water conditions on the shallow oil sands of Ohio. (15 min.).....KENNETH COTTINGHAM
52. The structure of the Clinton sandstone in Ohio and its relation to oil and gas accumulation. (15 min.).....ROBERT LOCKETT
53. Clinton sand structure of northern Ohio in its relation to production. (15 min.).....A. W. MELHORN
54. A structural feature of Wood County, Ohio. (10 min.)....J. ERNEST CARMAN
55. The decline of mining activity in Colorado. (30 min., lantern), FRANK R. VAN HORN
56. The glass sands of Ohio. (10 min.).....J. A. BOWNOCKER
57. Bacterial precipitation in fresh water. (15 min., lantern), ALLYN C. SWINNERTON
58. The significance to sedimentation of the Amherst Berea deposits. (15 min., lantern).....J. E. HYDE
59. Some broader correlations of the Richmond. (15 min., lantern), W. H. SHIDELER
60. The rock section at the O'Shaughnessey Dam. (10 min.)..J. ERNEST CARMAN
61. Effect of cutting upon the rate of hair growth. (5 min.)....R. J. SEYMOUR
62. Formation and structure of dental enamel. (15 min.)...SAMUEL W. CHASE
63. Status of the occupational disease question in Ohio, based on official figures. Present tendencies. (15 min., lantern)..EMERY R. HAYHURST
63. Recent studies on food accessories in a legume. (10 min.)..H. H. M. BOWMAN
64. Effect of basal metabolism of adrenalin by mouth. (10 min.), F. A. HITCHCOCK
65. Factors that influence the knee jerk. (15 min.).....W. W. TUTTLE
66. Effect of adrenalin on the temperature of the brain. (10 min.), W. P. SPENCER AND M. W. CASKEY
67. Relations of adrenals to bodily activities of the rat. (12 min.), E. P. DURRANT
68. The effects of syphilis on dentition and on tooth structure. (15 min.), L. J. KARNOSH
69. The nutritive value of a little-known bean. (10 min.).....H. H. M. BOWMAN
70. Blood sugar studies. (15 min.).....E. C. ALBRITTON
71. Calcium deficiency as a factor in psychopathy. (20 min.), FLORENCE MATEER
72. Psychological method of studying. (30 min.).....HAROLD E. BURTT
73. A study in the evolution of concepts. (30 min.).....GARRY C. MYERS
74. Utilizing college records, including appointment blanks to predict after-college success of students. (15 min.).....LAURA CHASSEL TOOPS
75. An investigation of the development of personality in children. (10 min.), O. R. CHAMBERS
76. Notes on musical aesthetics.....PAUL R. FARNESWORTH
77. The necessary postulates of empirical psychology. (15 min.), H. M. JOHNSON
78. The development of bisporangiate flowers in Sagittaria latifolia. (8 min.), JOHN H. SCHAFFNER
79. A case of teratological infloresence in alsike clover. (8 min.), FREDA DETMERS
80. Some new heritable characters of corn found in the culture at Ohio State University. Introduced by W. G. Stover. (10 min., lantern), MARION T. MEYERS
81. Studies of variation in the fleshy fungi. (15 min.).....H. C. BEARDSLEE
82. The trend of investigation in plant growth. (20 min.).....H. C. SAMPSON
83. The change of opposite to alternate phyllotaxy in hemp by means of photoperiodism. (10 min.).....JOHN H. SCHAFFNER
84. The physiology of stomata. (20 min., lantern).....J. D. SAYRE
85. The diffusion of water-vapor through small openings. (20 min., lantern), J. D. SAYRE
85. Water transfer in plant cells. (10 min.).....H. M. BENEDICT
86. The nutrition of Euglena gracilis. (10 min.).....W. J. KOSTIR
87. Some filamentous algae from Iowa. (10 min., lantern).....L. H. TIFFANY
88. The zygnemales. (15 min.).....E. N. TRANSEAU

89. The peculiar flora of the sand region west of Toledo. (10 min.), E. L. Moseley
90. The distribution of the pine in Ohio. (20 min., lantern).....Forest Dean
91. The economic features of the yellow poplar in Ohio. (15 min., lantern), O. A. Alderman
92. Progress report on plantings on the slope of the dams in the Miami Conservancy District. (25 min., lantern).....A. E. Waller
93. Observations of a plant collector on the Island of Hainan. (By invitation). Introduced by A. E. Waller. (30 min., lantern)...F. A. McClure
94. The uredinales of Ohio. (Preliminary). (10 min.).....W. G. Stover
95. The relation of weather conditions to the development of apple scab at Columbus in 1923. (12 min., lantern).....Howard W. Johnson
96. The infection period of apple blotch in central Ohio in 1923. (8 min., lantern).....Curtis May
97. The relation of Fusarium moniliforme to the ear, stalk and root-rot of corn. Introduced by W. G. Stover. (10 min., lantern)...D. P. Limber
98. Studies of toxin production in the fusarium wilt of tomato. Introduced by W. G. Stover. (10 min.).....Ivan E. Massar
99. A bud sport in pelargonium accompanied by the loss of two chromosomes. (Read by title).....Paul B. Sears

DEMONSTRATIONS.

a. Yellow poplar wood.....O. A. Alderman
b. Corn.....Marion T. Myers
c. Lower jaw of a boar showing tusks.....William E. Niehaus
d. Water snake (Tropidonotus fasciatus) in the act of swallowing a creek sucker.....F. A. Hannawalt
e. Skeleton mount of common mole (Scalopus aquaticus machrinus).W. H. Camp
f. Plaster cast of earthworm (Lumbricus terrestris). Cross section, Henry Olson
g. Examples of certain homoptera of the Southwest, with photographs of their habitats.....Herbert Osborn
h. Activity cages.....E. P. Durrant
i. The structure of dental enamel.....Samuel W. Chase
j. A novel form of symphalangism, or hypodactyly.....Ondess L. Inman
k. A new type of physiographic map.....Kirtley F. Mather

AN ANALYSIS OF THE CRANIAL GANGLIA OF AN EMBRYO SALAMANDER, AMBYSTOMA JEFFERSONIANUM (Green).

W. J. KOSTIR

Department of Zoology and Entomology
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Introduction.

Since the pioneer work of Strong (1895) on the nerve components of the cranial nerves of Amphibia, a number of other papers have appeared dealing with the composition of these nerves in various members of the same group. Most of these studies have dealt with various species of urodeles, and have been concerned more particularly with the peripheral distribution of the nerves in the adult or late larval forms.

In these late larval and adult stages the ganglia of the cranial nerves are invariably more or less fused, forming in the Anura two, in the Urodela usually three, general ganglionic masses. In consequence of this fusion, the fundamental relations of the individual ganglia are largely obscured, and the analysis of these ganglionic masses into their component parts is made exceedingly difficult and oftentimes impossible.

The importance of studying early embryonic stages in which the fusion spoken of above has not yet taken place, and in which, therefore, the primary relations of the ganglia still obtain, was emphasized by Landacre and McLellan's analysis of the cranial ganglia of the embryo of Rana (1912). The present paper is offered as an attempt to analyze, by the use of similar methods, the cranial ganglia of an embryo urodele.

Material.

Except where otherwise stated, the descriptions, drawings, and reconstructions which follow are from a single embryo of Ambystoma jeffersonianum (Green), 11.5 mm. in length. This embryo was killed about nineteen days after fertilization, most of the development having taken place in a room where the temperature was mild and fairly constant. Most of the remaining embryos of the same egg mass hatched six days later. A considerable number of other specimens, some younger and some older than the 11.5 mm. embryo, were also studied and the conclusions reached from the study of the latter were thus checked up.

It was found that considerable variation in position and in degree of fusion between the ganglia was present in embryos of approximately the same age. Even the two sides of the same individual often presented considerable differences. Nevertheless, the more general relations between the ganglia and between these and their roots and rami were found, on the whole, to remain constant. Likewise, while the degree of fusion between given parts might be considerably less in some older individuals than in certain younger ones, there was found to obtain in general a definite progression from the free to the fused condition paralleling the progression from early to late stages. The 11.5 mm. embryo described was selected because it showed what seemed to be, on the whole, the most typical condition for that stage.

The material was killed and fixed in Zenker's fluid, and after sectioning was stained with Delafield's hæmatoxylin and orange G. The studies were made almost entirely from transverse sections 10 microns in thickness, though two specimens cut into parasagittal sections of the same thickness were also used.

For this material, and for numerous suggestions and criticisms as well, I wish to acknowledge my deep obligation to Professor F. L. Landacre.

Scope and Methods.

While the cranial ganglia in the 11.5 mm. embryo are more crowded together than in earlier stages, and a certain amount of fusion has already taken place, this embryo was chosen for

detailed study and reconstruction because of the much more complete development of the nerve trunks and their branches. This made possible certain identification of the various ganglia, which was the main object of the present investigation. However, a detailed study of the distribution of the nerves was not attempted; and only as much of this distribution is given in the following description as seems necessary to establish the character of the several ganglia. For the sake of clearness and simplicity, the distribution of the nerves is not included in the reconstruction. For the same reason, while all motor components that were definitely identified as such are described in the text, these have been omitted from the reconstruction.

The lateral view reconstruction shown in Plate I was made by the ordinary method of projecting, by means of a camera lucida, sections magnified to a definite size upon coordinate paper, and plotting the upper and lower limits of the various structures in consecutive sections. The reconstruction is thus a projection of these structures upon the sagittal plane.

The nomenclature used has been, as far as possible, the same as that of Coghill (1902), whose thorough and painstaking description of the cranial nerves in the late larval stage of Ambystoma tigrinum was found of great assistance. To some extent, however, I have made use of the nomenclature of Landacre and other authors.

General State of Development of the 11.5 mm. Embryo.

In the 11.5 mm. embryo of Ambystoma jeffersonianum the general relations of the parts of the central nervous system are already essentially the same as in the adult, though the brain is comparatively shorter antero-posteriorly, and the cephalic flexure is more marked. The cranial ganglia are readily recognizable, and their roots and principal trunks and rami are for the most part well defined. In the preparations studied no trace of myelination of the fibers can as yet be detected; though usually numbers of elongated cells (the future sheath-cells) are strung along the bundles of fibers. A root or ramus when cut in cross-section often shows the nuclei of some of these cells in among the fibers. In many cases fibers can be traced directly to the muscles, sense-organs, or other tissues which they innervate; but for the most part this is very difficult, owing to the

absence of myelination and the obscuring presence of numerous yolk-laden mesenchyme cells.

At this stage of development the differences in size and staining reaction between the fibers of different components, reported by various writers, are not observable; except that when, as is rarely the case, isolated fibers are found, those from lateralis ganglia appear to be slightly larger than those from other ganglia.

The auditory vesicle, in the embryo here described, is in an early stage of the formation of the semi-circular canals; the septa of the lateral and anterior canals have just been formed, while that of the posterior canal is represented as yet only by an infolding of the lateral wall of the vesicle, which fold projects mesio-ventrad into the cavity of the latter. (Norris, 1892).

Lateral line organs are numerous on the side of the head, and readily recognized.

The skeletal system is in a very early stage of development. The chondrocranium is as yet represented only by the parachordals and the trabeculæ, which at this time are little more than narrow bars. The visceral arches (branchial bars) are fairly well defined. The palatoquadrate cartilages are not as yet fused with the trabeculæ. All these structures are in a very early stage of chondrification. Actual chondrification of the auditory capsule has not as yet commenced, though an organization of mesenchyme about the vesicle, preparatory to chondrification, is already apparent.

The pharynx is still closed anteriorly at this stage. Gill clefts have not yet appeared, but their future position is indicated by endodermic outgrowths from the wall of the pharynx to the spaces between the external gills. The breaking open of the mouth and that of the gill clefts seem to take place nearly at the same time, and but little later than the stage described.

The Ganglia of the V (Trigeminus), VII (Facialis), and VIII (Auditory) Nerves.

The ganglia of the V, VII, and VIII nerves fall distinctly into two groups. The Gasserian and dorsal lateralis VII ganglia comprise the more anterior group; the geniculate, ventral lateralis VII, and auditory ganglia comprise the more posterior. This grouping is not, however, as striking a feature as it seems

to be in some of the late larval forms hitherto described, the anterior border of the geniculate ganglion, for example, being barely 10 microns posterior to the most posterior portion of the Gasserian (Plate I). Later in the development (in the young larva) the lengthening of the head brings with it an increase in the distance between these ganglia; and the work of Coghill (1902) shows that this tendency becomes even more marked in the late larval stages.

Cutaneous V or Gasserian Ganglion.

The Gasserian ganglion, at this stage, is readily recognized as a rather large mass of cells, somewhat oblong in cross-section, and pressed close to the lower portion of the side of the medulla at the anterior end of the latter (Plate I, *G. Gass.* + *Prof.;* Plate II, Fig. 1, *G. Gass.;* Plate IV, Fig. 1a). Its anterior portion extends for a short distance into the region between the brain and the optic vesicle; its posterior part for a shorter distance into that between the brain and the auditory vesicle. Its ventro-lateral portion is in contact with the anterior extremity of the palatoquadrate bar (Plate II, Fig. 1; Plate IV, Fig. 1a).

At this stage no distinction can be made out with certainty between the profundus portion and the Gasserian proper portion of the ganglion. In considerably earlier stages, however, this distinction is very marked, the profundus portion projecting forward for a considerable distance above the optic vesicle. In these earlier stages both portions of the ganglion lie much closer to the ectoderm of the side of the head.

In its posterior part the dorsal portion of the Gasserian ganglion is in close contact with the dorsal lateralis VII ganglion (Plate I, and Plate II, Fig. 1, *G. D. L. VII*). The two are readily separated, however, because of the histological differences between them. (See p. 251; also Plate IV, Fig. 1a).

The root of the Gasserian ganglion leaves its dorso-mesial surface near the center of its posterior half. (See Plate I, dotted lines, and Plate II, Fig. 1, *Rt. Gass.*; also Plate IV, Fig. 1a). It is exceedingly short, entering the medulla at a point directly opposite its point of exit from the ganglion. In older stages the root becomes considerably longer, and runs caudad for some distance before entering the medulla; this is the condition which has been uniformly reported for late larval stages in urodeles.

Three rami arise from the Gasserian ganglion. The *ramus ophthalmicus profundus V* (Plate I, *R.O.P. V*) arises from its most anterior portion; it dips at first rather suddenly downward for a short distance, and then takes its course forward between the brain and the optic vesicle.

The *ramus maxillaris V* (Plate I, *R. Mx. V*) arises from the dorso-lateral part of the ganglion, at a transverse level nearly at the middle of the ganglion. It at once unites with the ramus buccalis VII to form the infra-orbital trunk, which takes its course at first latero-ventrad and a little forward, and then more directly forward between the optic vesicle and the skin, close to the outer surface of the former.

The *ramus mandibularis V* (Plate I; Plate II, Fig. 1; Plate IV, Fig. 1a; *R. Mnd. V*) leaves the lateral portion of the ganglion a few sections posterior to the origin of the ramus maxillaris, and at a point directly dorsal to the palatoquadrate bar. It runs at first latero-ventrad and then almost directly ventrad between the temporalis and masseter muscles to the region of Meckel's cartilage. The further course of its principal portion is in general cephalad. Fibers from it were traced directly to the undifferentiated ectoderm, below Meckel's cartilage, helping thus to confirm the general cutaneous character of the ganglion.

Motor component V. In the postero-ventral portion of the root of the Gasserian, a bundle of fibers may be recognized as a motor component because of the fact that its fibers, unlike the rest, after entering the medulla run down into its ventral horn. These fibers pass directly through the ganglion, emerging with and as a part of the ramus mandibularis, in which they occupy a postero-ventral position. A short distance beyond the ganglion a portion (at least) of these fibers is given off from the ventral side of the ramus mandibularis, and innervates the temporalis muscle, thus confirming the motor character of this component.

Dorsal Lateralis VII Ganglion.

Throughout most of its length this ganglion appears in cross-section as a more or less rounded or oblong mass dorsal to the Gasserian, to which for some distance it is closely pressed (Plate I; Plate II, Fig. 1; Plate IV, Fig. 1a; *G. D. L. VII*). Nevertheless, as stated above, the two can be readily distin-

guished. Its posterior portion extends backward between the auditory vesicle and the medulla, and gives rise to its root at a transverse level but little farther caudad than that of the posterior end of the Gasserian. This root, owing to the narrow space between the ear and the medulla through which it passes, is much compressed from side to side, giving it, in the reconstruction, a false appearance of great bulk (Plate I, *Rt. D. L. VII*). The root continues backward to its junction with the root of the ventral lateralis VII ganglion (Plate I; Plate II, Fig. 2; Plate IV, Fig. 2a). Slightly posterior to this junction the combined roots enter the medulla. This point of entrance is at a horizontal level much higher than that of the root of the Gasserian. (Plate I, dotted lines; also Plate II, Fig. 3, *Rt. D. + V. L. VII*).

The *ramus ophthalmicus superficialis VII* (Plate I, *R. O. S. VII*) leaves the dorsal lateralis VII ganglion at its anterior end. It passes forward and somewhat dorso-laterad for a considerable distance, running directly above the eye. Branches from it were traced to the lateral line organs of this region. No evidence was found of any other component in this ramus.

About four sections (40 microns) farther back the *ramus buccalis VII* (Plate I, *R. Bu. VII*) leaves the ventro-lateral portion of the ganglion, and at once joins with the cutaneous ramus maxillaris V to form the infra-orbital trunk. At the point where the two unite, a branch is given off posteriorly (Plate I; Plate II, Fig. 1; Plate IV, Fig. 1a; *R. Bu. VII, 1*) which runs ventro-laterad and for a short distance back around the anterior end of the auditory vesicle. Its fibers were traced to lateral line organs in this region. The general course of the main portion of the infra-orbital trunk has been given above (p. 235). Fibers from it were traced to numerous lateral line organs.

Ventral Lateralis VII Ganglion.

This, the farthest ventrally of all the ganglia here described, is a spindle-shaped mass of cells lying ventral to the anterior portion of the auditory vesicle (Plate I; Plate II, Figs. 2 and 3; Plate IV, Figs. 2a and 3a; *G. V. L. VII*). Its long axis is directed ventro-laterad and slightly caudad. Its proximal end is well fused with the distal portion of the geniculate ganglion, although, as in the case of the dorsal lateralis VII and Gasserian

ganglia, the boundary between the two is readily recognized. The distal end of the ganglion lies upon and in contact with an outgrowth of endoderm which projects dorsad from the lateral angle of the pharynx in this region (Plate II, Figs. 2 and 3; *En.*).

The root of the ventral lateralis VII ganglion is comparatively long (Plate I; Plate II, Fig. 2; Plate IV, Fig. 2a; *Rt. V. L. VII*); as it runs mesio-dorsad to its junction with the root of the dorsal lateralis ganglion, it is pressed between the geniculate ganglion, the auditory vesicle, and the anterior border of the auditory ganglion.

But one ramus arises from this ganglion, the *ramus mentalis VII* (Plate I; Plate II, Fig. 3; Plate IV, Fig. 3a; *R. Mnt. VII*). This component of the hyomandibular trunk leaves the distal extremity of the ganglion; it passes, just posterior to the articulation of Meckel's cartilage with the palatoquadrate bar, abruptly ventrad and lateral to the hyoid bar. When close to the ectoderm in the ventro-lateral region of the head it turns forward, supplying lateral line organs in this region and farther cephalad. A short distance from the ganglion it gives off a lateral branch which passes directly to the skin and likewise innervates lateral line organs.

Visceral VII or Geniculate Ganglion.

The geniculate ganglion (Plate I; Plate II, Figs. 2 and 3; Plate IV, Figs. 2a and 3a; *G. Gen.*) is directly posterior to the Gasserian, and in the 11.5 mm. embryo it almost touches the posterior border of the latter. In its anterior portion it is roughly wedge-shaped as seen in cross-section, the point of the wedge extending dorsad between the medulla and the ear (Plate II, Fig. 2; Plate IV, Fig. 2a). Posteriorly the ganglion is pressed close against the antero-mesial surface of the auditory ganglion, the anterior end of which is introduced between the geniculate ganglion and the ear (Plate II, Fig. 3; Plate IV, Fig. 3a; *G. Aud.*). This contact between the two ganglia is very close, and in some specimens it is very difficult to distinguish the exact boundary between the two.

The root of the geniculate ganglion (Plate I; Plate II, Fig. 3; Plate IV, Fig. 3a; *Rt. Gen.*) arises from its postero-dorsal portion; it passes dorsad and caudad for a short distance, pressed close to the mesial surface of the auditory ganglion, and enters the medulla at a horizontal level lower than the

lateralis root of VII, yet somewhat higher than the root of the Gasserian. The area of entry is but two or three sections (20 or 30 microns) farther caudad than that of the lateralis root.

Two rami arise from the geniculate ganglion. The *ramus alveolaris VII*, the visceral component of the hyomandibular trunk, leaves the ventro-lateral portion of the ganglion, directly underneath the proximal end of the ventral lateralis VII ganglion (Plate I, *R. Alv. VII*). It proceeds parallel to the long axis of this latter ganglion, in close contact with its ventral surface (Plate II, Fig. 3; Plate IV, Fig. 3a), and soon turns abruptly ventrad, running parallel and mesial to the ramus mentalis, but quite distinct from it. At about the horizontal level of the middle of the pharynx it turns forward and runs cephalad. When traced forward it is soon lost, its fibers apparently ending in the epithelium of the pharynx.

The *ramus palatinus VII* (Plate I, *R. Pal. VII*) leaves the antero-ventral portion of the ganglion and inclines cephalo-ventrad. Its fibers also end in close relationship with the epithelium of the pharynx.

Auditory Ganglion.

The auditory ganglion (Plate I; Plate II, Figs. 3 and 4; Plate IV, Figs. 3a and 4a; *G. Aud.*) lies between the ventral portion of the auditory vesicle and the medulla, and throughout most of its length is in contact with the former. Its anterior portion is wedged in between the ear and the geniculate ganglion (Plate II, Fig. 3; Plate IV, Fig. 3a), and its anterior-most border is in contact with the root of the ventral lateralis VII ganglion. Its dorso-ventral extent is much greater anteriorly than farther back, reaching from a level below the base of the medulla to a level just above the area of entry of the root of the geniculate. Posteriorly it tapers, somewhat more rapidly on its upper surface, and reaches as far as the posterior third of the auditory vesicle.

The only root of the auditory ganglion recognized with certainty as such leaves its dorso-mesial portion, and, passing slightly caudad and dorsad, enters the medulla in contact with and ventro-posterior to the root of the geniculate (Plate I, *Rt. Aud.*). It is in even closer relationship with the motor root which leaves the medulla just ventral to it; the exact limits of these roots are very hard to distinguish.

Coghill describes two auditory ganglia, a vestibular and a cochlear, each with its own root, in the late larval stage of Ambystoma. Norris finds two auditory roots in Amphiuma, but does not distinguish two distinct ganglia, merely recognizing vestibular and cochlear portions of one auditory ganglion. In the embryo here described it has likewise been impossible to distinguish two distinct ganglia. In young larval stages considerably older than the 11.5 mm. embryo, two different regions, one more anterior and dorsal, the other more posterior and ventral, may be identified. These regions are characterized by histological differences (p. 252), but no definite boundary between them can be determined. In the 11.5 mm. embryo the beginnings of this histological differentiation can be just barely recognized, and the transition in structure from one portion of the ganglion to the other is even more gradual than in later stages.

Only two rami from the auditory ganglion, both of them small and unbranched, are present in the 11.5 mm. embryo. The larger and more anterior of these (Plate II, Fig. 3; Plate IV, Fig. 3a; *R. Utr. VIII;* not shown in reconstruction) arises from the ventro-lateral portion of the ganglion, near its anterior end, and passes laterad in close contact with the ventral surface of the auditory vesicle to the macula of the utriculus; a few of the fibers appear to pass beyond to the crista of the horizontal canal. The smaller and more posterior ramus (Plate II, Fig. 4; Plate IV, Fig. 4a; *R. Sac. VIII;* not shown in reconstruction) arises from the postero-lateral portion of the ganglion and passes laterad to the macula of the sacculus. These small rami are undoubtedly the incipient *ramus acusticus utriculi* and *ramus acusticus sacculi* respectively.

Motor component VII. Immediately ventral to the area of entry of the auditory root a bundle of motor fibers emerges from the medulla. The character of this component is indicated by the course of the fibers within the medulla, where they are readily traced to the ventral horn, and is confirmed by their peripheral distribution. The component extends ventro-laterad, pressed close between the auditory and geniculate ganglia (Plate II, Fig. 3; Plate IV, Fig. 3a), and as it emerges from between them it comes to lie on the posterior surface of the ventral lateralis ganglion. Thence it continues ventro-laterad for a short distance, and its fibers enter the depressor mandibulæ muscle. At all points its fibers are quite distinct from those of the remainder of the hyomandibular trunk.

The Ganglia of the IX (Glossopharyngeus) and X (Vagus) Nerves.

At the stage of the 11.5 mm. embryo the ganglia of the IX-X complex are in a condition intermediate between the earliest stage of well-defined and almost entirely separate ganglia and the later stage of complete fusion into one ganglionic mass. The ganglia are already crowded together, and to some extent actual fusion has taken place. For the most part, however, the limits of the individual ganglia are readily discernible.

In the more general relations of its parts this group bears a distinct resemblance to the same complex in the embryo of Rana, as reported by Landacre and McLellan. The visceral ganglia—visceral IX, or petrosal, and visceral X, or nodosal—are ventral in position; the one cutaneous ganglion—cutaneous X, or jugular—more dorsal and mesial; while the lateralis ganglia, present, as in Rana, in both IX and X, occupy a position dorsal and lateral to the other ganglia of the complex.

The roots of these ganglia enter the medulla in three distinct areas. Of these, the most anterior is that of the one lateralis root of the complex, composed of all the lateralis root fibers from both IX and X. Slightly caudad and ventrad of this enters the root of the visceral IX ganglion; and considerably farther back the roots of the visceral X and cutaneous X ganglia enter together.

These relations are essentially the same as those described by Coghill for the late larval stage of Ambystoma, except that he describes two roots for visceral X, entering the medulla separately. This I have not been able to demonstrate in the 11.5 mm. embryo, nor in any of the other stages at hand. All the visceral root fibers from X apparently enter the medulla together.

Visceral IX or Petrosal Ganglion.

The most anterior of the ganglia of the IX-X complex is the visceral IX (G. petrosum). (Plate I; Plate III, Figs. 5, 6, and 7; Plate IV, Figs. 5a, 6a, and 7a; *G. Vi. IX*). It lies immediately posterior to the auditory vesicle, its dorso-anterior portion extending mesial to the posterior extremity of the latter. In cross-section it is more or less oval in shape, and the long axis is inclined ventro-laterad.

The root of the visceral IX ganglion (Plate I, *Rt. Vi. IX*) arises from its antero-dorsal portion, and passes forward and mesio-dorsad for about eight sections (80 microns) before entering the medulla. The area of entry is ventro-posterior to that of the lateralis IX and X root; its horizontal level (with respect to the base of the medulla) is nearly the same as that of the root of the geniculate ganglion. Motor fibers were recognized in this root, in the same way as in the roots of V and VII, but I was not able to trace them through the ganglion.

The one nerve that leaves this ganglion, the *truncus glossopharyngeus IX* (Plate I; Plate III, Fig. 5; Plate IV, Fig. 5a; *T. Gl. IX*), arises from its ventro-lateral border and passes ventro-laterad and slightly cephalad to the region of the first branchial bar. A short distance beyond the ganglion a small branch (not shown in the reconstruction) is given off ventrally, and passes ventro-cephalad. It could not be traced very far, but apparently ends while in close relationship with the epithelium of the pharynx.

Just above the first branchial bar the glossopharyngeal trunk passes close to the first levator arcus branchialis muscle, and a portion of its fibers (motor component of IX) enter this muscle. The principal portion of the trunk turns cephalad, and extends in this general direction for a long distance, at first lateral to the first branchial bar, but gradually passing ventrad and mesiad; it finally ends in the epithelium of the basal portion of the tongue. It should be noted here that this is not the complete distribution of the glossopharyngeal trunk. As in the case of other trunks and rami, minor branches were not followed.

The *ramus communicans IX + X ad VII*, described by Coghill, Bowers, and Norris as present in the late larval stages of Ambystoma, Spelerpes, and Amphiuma respectively, could not be found in any of the embryos or young larvæ which I studied.

Coghill finds in the late larva of Ambystoma a cutaneous component in the truncus glossopharyngeus, apparently derived from the cutaneous X ganglion. This, again, I was not able to demonstrate in the material at hand.

Lateralis IX and X Root.

Before taking up any of the lateralis ganglia of IX and X, a few words regarding the common root of these ganglia (Plate I,

Rt. L. IX + X) will prove helpful. The most posterior portion of this root arises from the dorsal lateralis X ganglion (Plate I, *G. D. L. X*), well back in the complex, and extends cephalad, for most of the distance dorsal to the cutaneous X ganglion (Plate III, Figs. 6, 7, and 8; Plate IV, Figs. 6a, 7a, and 8a; *Rt. L. X; G. Cu. X*) as far as the lateralis IX ganglia (Plate I; Plate III, Figs. 5 and 6; Plate IV, Figs. 5a and 6a; *G. D. L. IX* and *G. V. L. IX*). As it passes close to the mesial surface of the latter, the root fibers of these ganglia are added to it. Running dorsal to the visceral IX root, it continues cephalad, and now somewhat dorso-mesiad, to its area of entry into the medulla. This area is antero-dorsal to that of the visceral IX root, and is nearly at the same horizontal level as that of the lateralis roots of VII.

On one side of one individual, a radical variation was found, the lateralis root of X entering the medulla quite separate from that of IX, and a short distance farther caudad than the lateralis and visceral roots of IX. What significance, if any, this interesting variation may have, it is impossible to say; the mere possibility that it is a reversion to a more primitive condition naturally suggests itself.

Lateralis IX Ganglia.

In the earlier stages there are two distinct lateralis ganglia present in close relationship with the visceral IX ganglion. Each sends its own root to join the general lateralis root of IX and X. From the more anterior and ventral of these ganglia the ramus supratemporalis IX arises; from the more posterior and dorsal, the lateralis component of the ramus auricularis IX + X. These two ganglia usually soon fuse, to a greater or less degree, and in the 11.5 mm. embryo they appear as one continuous ganglion. (Plate I; Plate III, Figs. 5 and 6; Plate IV, Figs. 5a and 6a; *G. D. L. IX* and *G. V. L. IX*). The apparent bilobing of this ganglion in the reconstruction does not accurately represent this double condition, though roughly it does; the more ventral of the ganglia is represented by a portion of the upper lobe as well as all of the lower.

In some individuals of stages somewhat older than the 11.5 mm. embryo, and even in a few of that stage, the dorsal lateralis IX ganglion comes into close contact with the ventral lateralis X ganglion, forming with it a single, continuous mass of cells.

From a study of such cases alone it would be easy to infer that the two actually represent but a single ganglion, and that the lateralis component of the R. auricularis therefore arises from ventral lateralis X. Against this interpretation, however, must be placed the indisputable fact that the cell masses which form these two ganglia are uniformly quite distinct in the early stages, and in the greater number of cases remain distinct for a considerable time, even after the development of the nerves to which they give rise.

Because of the close relationship of both dorsal and ventral lateralis IX to the visceral IX ganglion, and because of their usual fusion with each other, it seemed best to place both these ganglia on IX. However, it seems quite possible that the ganglion identified as dorsal lateralis IX actually belongs primitively on X, and corresponds to the first of the three lateralis ganglia on X which Landacre has described in Squalus. Either interpretation is bound to be more or less arbitrary.

In the 11.5 mm. embryo the greater part of the combined lateralis IX ganglia lies directly above the visceral IX ganglion, and in contact with the lateral border of the lateralis IX and X root (Plate III, Fig. 5; Plate IV, Fig. 5a). The individual roots of both lateralis IX ganglia can be distinguished, though with great difficulty, as both are exceedingly short before they unite with the root of lateralis X.

The combined lateralis IX ganglia comprise a comparatively small mass of cells; the most ventral portion, as seen in transverse section, consists merely of a single or at most a double layer of cells pressed close to the dorso-lateral border of the visceral IX ganglion. The appearance of this ventral portion in the reconstruction is deceptive, its size as seen in the lateral view giving the idea of considerable bulk, which it does not possess. (Compare Plate I with Plate III, Figs. 5 and 6.) The cells of this ventral portion extend down toward the point of origin of the truncus glossopharyngeus, and in some specimens strongly suggest the idea that they may send lateralis fibers into this trunk. However, no such fibers could be traced with certainty; and as far as the distribution of the glossopharyngeal trunk was followed, no lateral line organs could be found to be innervated by its fibers.

The actual number of rami from lateralis IX seems to vary somewhat with the age. In the 11.5 mm. embryo there are three

definite rami (Plate I; Plate III, Figs. 5 and 6; Plate IV, Figs. 5a and 6a; *R. Spt. IX;* and *R. Aur. 1, IX* and *R. Aur. 2, IX*) and one slight fibrous outgrowth which does not as yet extend far beyond the surface of the ganglion (Plate III, Fig. 5; Plate IV, Fig. 5a; *R. Aur. ?*, not shown in the reconstruction). A study of many individuals of various stages shows that these rami fall distinctly into two groups, each group arising from a different one of the two original ganglia of which lateralis IX is composed. The distribution of these two groups corresponds in a general way with that usually given for the ramus supratemporalis and ramus auricularis respectively. Moreover, the more posterior of these groups is almost invariably closely associated near its place of origin with a component from the cutaneous X ganglion, while the other is not. As this also agrees with the conditions of the two rami as reported in late larval stages of both Ambystoma and Amphiuma, there seems to be no doubt of the homology.

In the 11.5 mm. embryo the *ramus supratemporalis IX* (Plate I; Plate III, Fig. 5; Plate IV, Fig. 5a; *R. Spt. IX*) arises from the antero-lateral portion of the combined lateralis IX ganglia. It passes laterad and somewhat dorso-cephalad around the hind border of the auditory vesicle and innervates lateral line organs in the region of the posterior portion of the ear. Its subdivisions seem to vary in different individuals, but in most it shows two main branches, one more dorsal than the other.

The two rami which I have identified as lateralis components of the *ramus auricularis IX + X* (Plate I; Plate III, Fig. 6; Plate IV, Fig. 6a; *R. Aur. 1, IX* and *R. Aur. 2, IX + X*) arise from the dorso-lateral portion of the combined ganglia, a little farther caudad and considerably farther dorsad than the origin of the ramus supratemporalis. They arise together, the more anterior (*R. Aur. 1*) extending dorso-laterad and then a little cephalad. The other (*R. Aur. 2*) inclines more caudad; it unites at once upon leaving the ganglion with fibers from the cutaneous X ganglion, and runs latero-dorsad, and for a short distance caudad, to the ectoderm. Fibers from both these rami were traced to lateral line organs in the region just posterior to the ear.

Cutaneous X or Jugular Ganglion.

Of the four ganglia of X, the cutaneous X or jugular ganglion (Plate I, *Rt. G. Cu. X;* Plate III, Figs. 6, 7, and 8; Plate IV,

Figs. 6a, 7a, and 8a; *G. Cu. X*) is closest to the wall of the medulla. It also extends the farthest forward, its anterior portion projecting cephalo-laterad between the dorsal lateralis IX, above, and ventral lateralis IX, together with visceral IX, below. (See Plate III, Fig. 6; Plate IV, Fig. 6a.)

As was stated above, the lateralis X root passes cephalad close to the dorsal surface of the cutaneous X ganglion; a small portion of the ganglion extends slightly dorso-mesial to this root (Plate III, Figs. 6 and 7; Plate IV, Figs. 6a and 7a). Lateral to the cutaneous ganglion lie the anterior portions of the ventral lateralis X and visceral X ganglia, the visceral X being crowded close against most of the lower portion of its lateral border (Plate III, Figs. 7 and 8; Plate IV, Figs. 7a and 8a). The limits of the two ganglia, are, nevertheless, readily distinguished.

The root of the cutaneous X ganglion (Plate I, *Rt. G. Cu. X;* Plate III, Figs. 6 and 7; Plate IV, Figs. 6a and 7a; *Rt. Cu. X*) arises from its dorso-mesial portion; it passes dorso-mesiad, in company with the root of the visceral X ganglion and a portion of the motor fibers of X, directly to the medulla. This combined cutaneous, visceral, and motor root is very thick. The horizontal level of its area of entry into the medulla, with reference to the base of the medulla, is somewhat lower than that of the Gasserian or geniculate roots; but since the height of the medulla at this point is considerably less than in the region of V and VII, relatively the level is approximately the same.

The only ramus from this ganglion that could be identified with certainty as such was the cutaneous component of the *ramus auricularis IX + X* (Plate I; Plate III, Fig. 6; Plate IV, Fig. 6a; *R. Aur. 2, IX + X*). This arises from the most anterior and lateral portion of the ganglion, just ventral to the posterior portion of the dorsal lateralis IX ganglion, and at once joins with the lateralis component from the latter. The two pass dorso-laterad and somewhat caudad to the ectoderm of the region just posterior to the ear. Some of the fibers were traced to undifferentiated ectoderm, confirming the cutaneous character of this component.

The cutaneous components found by Coghill in the glossopharyngeal trunk and in both branchial trunks in the late larval stage of Ambystoma, I was not able to demonstrate with certainty in my material.

Visceral X or Nodosal Ganglion.

In the earlier stages the visceral X ganglion (G. nodosum) (Plate I; Plate III, Figs. 7, 8, and 9; Plate IV, Figs. 7a, 8a, and 9a; *G. Vi. X*) shows a very evident division into two parts, the more anterior of these giving rise to the two branchial trunks, the posterior to the visceral trunk. The two portions are continuous with each other, the division between them being marked simply by a very decided constriction in the middle portion of the ganglion.

This division of the visceral X ganglion into two parts, a branchial and a visceral, was also found by Landacre and McLellan in the embryo of Rana. The possible homology of the anterior portion with one or more of the branchial ganglia of fishes is discussed by these authors. A comparison with the visceral ganglia of X in Menidia (Herrick, 1899) or Squalus (Landacre, 1916) strongly suggests the probability of such a homology.

In the 11.5 mm. embryo from which the reconstruction was made, the constriction between the two portions of the visceral X ganglion has disappeared, and the ganglion appears as a single large, elongated mass, which is somewhat larger in transverse extent in the region of the branchial trunks than farther back. In some specimens, however, this constriction persists to a much later stage of development.

Anteriorly the visceral X ganglion extends, together with the ventral lateralis ganglion just above it, for a slight distance latero-dorsal of the visceral IX ganglion. Its anterior third is in close contact with the lower portion of the lateral surface of the jugular ganglion. Throughout most of its extent, the lateralis X ganglia lie in close contact with its dorsal, and to some extent lateral, surfaces, as will be described below.

The root of the visceral X ganglion (Plate I; Plate III, Figs. 6, 7, and 8; Plate IV, Figs. 6a, 7a, and 8a; *Rt. Vi. X*) leaves its dorso-mesial surface, a little caudad of the posterior border of the cutaneous ganglion. It passes, at first pressed close to the posterior surface of the latter ganglion, dorso-mesiad and somewhat cephalad to the medulla, which it enters in company with the cutaneous root and a portion of the motor root of X.

The visceral components of the two *branchial trunks* (Plate I; Plate III, Fig. 8; Plate IV, Fig. 8a; *T. Br. 1, X* and *T. Br. 2, X*) leave the ganglion close together. They arise from its ventro-lateral border, not far from its anterior end, the place of origin of the second branchial trunk being usually just posterior to that of the first. The course of the first of these is in general ventro-laterad and somewhat caudad; that of the second is similar, but more caudad.

A short distance beyond the ganglion a ventral branch (not shown in the reconstruction) leaves the first branchial trunk; it inclines ventro-caudad and soon disappears in contact with the epithelium of the pharynx. This is evidently the "pharyngeal ramus, 1 br. 1," of Coghill (1902, Plate XVI).

On their way to the periphery, both branchial trunks come into close relations with certain small gill muscles (not identified); and it appears quite probable that motor fibers present in these trunks are given off to these muscles, as Coghill found to be the case in the late larval stage. This could not be demonstrated, however, in the 11.5 mm. embryo. The greater portion of the fibers of these trunks passes to the region of the three external gills.

The *truncus visceralis X* (Plate I, *T. Vi. X*) leaves the posterior extremity of the visceral X ganglion and extends ventro-caudad. A very short distance beyond the ganglion a lateral branch (Plate I, *T. Vi. X. 1*) leaves the trunk and extends latero-caudad to the region of the third external gill. The main portion of the trunk continues ventro-caudad and comes into close relations with the alimentary canal in the region posterior to the gills. A portion at least of its fibers may be traced to the epithelium of the alimentary canal in this region.

Dorsal Lateralis X Ganglion.

This ganglion (Plate I, *G. D. L. X*) lies throughout its whole extent dorsal to the visceral X, and posteriorly becomes in some individuals partially fused with it (Plate III, Fig. 9; Plate IV, Fig. 9a). Its anterior end is at about the transverse level of the visceral X root; its posterior end about as far caudad as the posterior end of the visceral ganglion. In early stages it is quite separate from the ventral lateralis X, but in the 11.5 mm. embryo the latter has become fused with a portion of its ventro-lateral border. (Plate III, Fig. 9; Plate IV, Fig. 9a).

The root of the dorsal lateralis X ganglion has been described above as the most posterior portion of the lateralis IX and X root. (See pp. 241 and 242).

But one ramus leaves the dorsal lateralis X ganglion, the *ramus lateralis superior X* (Plate I, *R. L. s. X*), which is purely lateralis in character. It arises from the posterior extremity of the ganglion and extends directly caudad. A short distance beyond the ganglion a branch is given off dorsally (Plate I, *R. L. s. d. X*), which after ascending a little continues caudad more or less parallel with the main portion of the ramus. Both portions supply lateral line organs along the dorsal portion of the side of the body.

Ventral Lateralis X Ganglion.

Up to the present time two lateralis ganglia on X have been definitely described for Amphibia only by Landacre and McLellan in the embryo of Rana. The more general relations of the ventral lateralis X ganglion in that form are almost exactly the same as those of the ganglion to which I have given that name in the embryo of Ambystoma. (Plate I; Plate III, Figs. 7, 8, and 9; Plate IV, Figs. 7a, 8a, and 9a; *G. V. L. X*).

In all the stages studied, this ganglion lies in contact with the dorso-lateral surface of the visceral X ganglion; and this contact is maintained usually throughout its whole length. In the later stages studied it is usually fused more or less completely with the dorsal lateralis IX ganglion and the ventral border of the dorsal lateralis X. In early stages, however, it is uniformly quite distinct from both of these. In the 11.5 mm. embryo from which the reconstruction was made, the process of fusion had gone farther on one side of the body than on the other. On the right side, which was plotted, the ventral lateralis X ganglion, while close to lateralis IX, was quite separate from it; on the left side the two had come into contact, though the limits of each were still recognizable. On both sides of the body the dorsal and ventral lateralis X ganglia were already partly fused. (Plate I; Plate III, Fig. 9; Plate IV, Fig. 9a).

In its anterior portion the ventral lateralis X ganglion extends much farther dorsad than it does farther back, its dorsal border rising to the level of the root of the dorsal lateralis X ganglion, and lying just lateral to it. (Plate I; Plate III, Fig. 7; Plate IV, Fig. 7a). At no point in this region, however,

is there the least indication of fusion or connection with this root. Just below this root the ganglion is in contact with a portion of the lateral border of the cutaneous ganglion. This anterior portion of the ventral lateralis ganglion comprises, in most specimens, the greater portion of its bulk. Just posterior to the point of origin of the second branchial trunk, the ganglion becomes perceptib'y smaller, sometimes dwindling away to a mere layer only a cell or two in thickness, closely applied to the surface of the visceral ganglion. Occasionally beyond this point it seems to disappear completely for a few sections. This suggests the idea that it may consist primitively of two ganglia, one anterior, the other posterior. To settle this point further study is necessary.

It may be noted here that all of the lateralis ganglia, in VII, IX, and X, invariably lie lateral to any other ganglia that may happen to be in the same horizontal plane with them. A glance at the reconstruction (Plate I) will make this evident. The same thing is true of the lateralis ganglia in the embryo of Rana, as shown by the reconstructions accompanying the paper of Landacre and McLellan.

No separate root of the ventral lateralis X ganglion could be found in any of the stages studied. Although, as stated above, the ganglion comes into close proximity to the dorsal lateralis root, no fibers pass from it to this root in this region. It is noteworthy that in the embryo of Rana, likewise, no separate root of the ventral lateralis X ganglion was found.

From the posterior end of the ventral lateralis X ganglion arises the lateralis component of the visceral trunk, the *ramus lateralis inferior* (Plate I, *R. L. i. X*), which passes ventrocaudad in company with the remaining components of the visceral trunk. In most transverse sections it is extremely difficult to be certain of the presence of this component in even the most proximal portion of the trunk. In parasagittal sections, however, the relation of its fibers to the cells of the ventral lateralis ganglion is absolutely unmistakable.

In the region of the origin of the branchial trunks from the visceral ganglion, the ventral lateralis ganglion presents very strongly an appearance of contributing fibers to these trunks, and this appearance is given added force by the large size of the ganglion in this region, coupled with the fact that no other ramus arises from this portion. It is true that the rela-

tions here are confused by the fact that fibers of another component, either cutaneous or motor (possibly both), passing down from the cutaneous ganglion, and then between the ventral lateralis and visceral ganglia, enter the branchial trunks at this point. Nevertheless, the appearance mentioned is too striking and too definite to be explained entirely as due to confusion with these other fibers.

But, in spite of repeated and most careful study of this point, I have not succeeded in tracing fibers from the branchial trunks to unmistakable lateral line organs. Moreover, Coghill found no lateralis fibers in these trunks in the late larval stage of Ambystoma, and, to the best of my knowledge, they have not been described as present there in any other form, either among fishes or Amphibia.

What, then, is the significance of this rather large mass of cells making up the anterior and larger portion of what I have called the ventral lateralis ganglion? One possibility that naturally occurs to one is that this ganglion actually sends lateralis fibers into the branchial trunks in the embryo, but that this is merely a rudimentary and transitory condition, disappearing by the time the late larval stage is reached. I am forced to say that, considering all the relevant facts, this hypothesis does not seem a very probable one. Another, and even more extreme possibility, is that this group of cells is not part of the lateralis system at all; that it is, perhaps, a special visceral ganglion, which sends gustatory fibers down the branchial trunks to innervate taste-buds in the region of the gills. It will be recalled that the cells comprising the most ventral portion of the ventral lateralis IX ganglion similarly give the appearance of sending fibers into the glossopharyngeal trunk, where I have not been able to demonstrate the presence of lateralis fibers by following the distribution, and where, likewise, they have never been found in other vertebrates.

Strong evidence against the possible special visceral character of these portions of the ventral lateralis IX and ventral lateralis X ganglia is afforded by their histological character. (See p. 252). The lateralis ganglia in general present the most distinctive appearance of any of the components, largely due to the uniformly larger size, rounded form, and lighter staining reaction of their cell nuclei. In these and all other respects that I have noted, the questionable portions of the two ganglia under

discussion are absolutely indistinguishable from any other portions of any of the lateralis ganglia. In the few cases where special visceral ganglia have been definitely identified in embryonic stages, as in Ameiurus (Landacre, 1910) and in Lepidosteus (Landacre, 1912), their histological appearance has been unmistakably different from that of the lateralis ganglia.

It is interesting to note that a number of rather small lateral line organs are present on the operculum, close to the bases of the gills; but, while fibers from the branchial trunks can be readily followed to this general region, and pass in close proximity to these lateral line organs, I have not been able to trace them to the organs with certainty.

Motor X component. The motor component of X leaves the medulla by several areas of exit. A portion of the fibers leave the medulla just ventral to the area of entry of the large cutaneous and visceral root; the rest by three other areas of exit, at about the same level, and posterior to this point. The fibers from these posterior areas of exit pass forward to the visceral and cutaneous root, and are soon indistinguishable among its fibers. Their further distribution was not studied.

Histological Characters of the Ganglia.

The nuclei of the cells of the cranial ganglia, in the preparations studied, stand out for the most part with great distinctness. The chromatin is not collected largely in a central nucleolus, as is the case in the embryo of Rana, but is distributed rather uniformly throughout the nucleus. (Compare detail drawings, Plate IV, with similar drawings accompanying Landacre and McLellan's paper on Rana.) The limits of the cytoplasm of the individual cells it is usually impossible to make out, at least within the ganglia. It is apparent, therefore, that any histological differentiation between the different ganglia that we may be able to recognize must be largely a matter of the appearance of the nuclei of the cells.

The size, shape, and depth of staining of the nuclei in a given ganglion, or in the ganglia belonging to a given system (cutaneous, lateralis, etc.) varies considerably. Nevertheless, this variation in a given case has its limits, as far as any considerable number of the nuclei are concerned, and, with the exception of cases which will be discussed below, the ganglia of a given system have a fairly uniform appearance.

In the 11.5 mm. embryo the most striking contrast in histological appearance between different ganglia is that between the lateralis ganglia and all the others. The nuclei of the cells of the lateralis ganglia are larger and rounder, and do not stain as heavily with Delafield's hæmatoxylin as do the nuclei of other ganglia. (See Plate IV, Figs. 1a, 2a, 3a, 5a, 6a, 7a, 8a, and 9a). They thus stand out in strong contrast, and even when the lateralis ganglia are practically fused with other ganglia, the limits of each are readily recognized by reason of these differences.

In stages younger than the 11.5 mm. embryo, these differences become less pronounced, and in the earliest stage where the ganglia are distinctly recognizable, can hardly be detected. The degree of contrast varies also in different specimens to a very great extent, due probably, largely if not entirely, to differences in fixation, staining, etc.

Between the cutaneous and visceral ganglia it is harder to detect differences of histological appearance. On the whole, the nuclei of the visceral ganglia seem to stain a little heavier than those of the cutaneous ganglia, for the most part are packed together a little closer, and perhaps average a trifle smaller. The variation is considerable, however, and sections can be found showing exactly the reverse condition.

Of the two regions of the auditory ganglion spoken of on page 239, the nuclei in the more anterior and dorsal region are very slightly larger, slightly lighter-staining, and not packed quite so close together as those in the ventro-posterior portion. These differences are exceedingly slight in the 11.5 mm. embryo; in the oldest of the early larval stages studied they have become much more pronounced, and the contrast between the two regions of the ganglion is very striking.

In the earlier embryonic stages studied two kinds of coloring material are present in the cytoplasm of the ganglion cells: yolk granules and pigment granules. The latter, as seen under the 4 mm. objective, are mere specks, of a brownish color, and identical in appearance with the pigment granules visible at the same time in the cells of the ectoderm. The yolk granules are larger, of various shapes, and stain much like the cytoplasm itself—usually a little darker. As development proceeds these yolk granules are apparently absorbed; in the 11.5 mm. embryo they are no longer present in the ganglion cells, though still

numerous in muscle and loose mesenchyme cells. At the same time the pigment granules undergo changes. In the 11.5 mm. embryo the lateralis ganglia are for the most part well pigmented, but the pigment, now of a yellowish-brown color, is uniformly spread through the cytoplasm of the cells, and the individual granules are not visible under the 4 mm. objective. In the other ganglia, the pigment is almost entirely absent. This furnishes another means by which, in many preparations, the lateralis ganglia are readily distinguished from the others.

Summary.

In late larval and adult stages of urodeles the ganglia of the cranial nerves are usually closely fused into three ganglionic masses. To learn the primary relations of the individual ganglia of these nerves, embryonic stages must be studied in which this fusion has not yet taken place, or in which it has not proceeded very far. The descriptions in this paper are of such stages.

In the 11.5 mm. embryo of Ambystoma jeffersonianum, the more general relations of the ganglia of the V and VII nerves are essentially the same as reported by Coghill in the late larval stage of Ambystoma tigrinum.

The Gasserian or cutaneous V ganglion lies close to the lower portion of the anterior end of the medulla, in the region between the optic and auditory vesicles. At this stage a separate profundus portion can not be distinguished in the Gasserian, but this distinction is very marked in the earlier stages.

The dorsal lateralis VII ganglion lies dorsal to the Gasserian ganglion.

The geniculate or visceral VII ganglion is posterior to the Gasserian, and except for its most ventral portion, lies in the space between the auditory vesicle and the medulla.

The ventral lateralis VII ganglion lies under the anterior end of the auditory vesicle, ventro-laterad of the geniculate ganglion, to which its proximal end is fused.

Only a single auditory ganglion could be recognized, in which, however, two different regions could be distinguished. These are characterized by histological differences, which are much more marked in the later stages studied.

In essential features the IX-X complex in the 11.5 mm. embryo is similar to that reported by Landacre and McLellan in Rana.

The visceral IX ganglion (G. petrosum) is quite separate from the visceral X; it lies just posterior to the auditory vesicle.

In earlier stages two distinct lateralis ganglia are present on IX, one of which gives rise to the ramus supratemporalis, the other to the lateralis component of the ramus auricularis. In the 11.5 mm. embryo these have united; the combined ganglia lie dorsal to the visceral IX.

Of the ganglia of X, the cutaneous or jugular is most mesial, and is close to the medulla. The cutaneous component of the ramus auricularis was the only component from it that was recognized with certainty, but its large size makes it probable that it sends components to other nerves as well.

The visceral X ganglion (G. nodosum) has a position posterior to the visceral IX and lateral to the cutaneous X. In stages earlier than the 11.5 mm. embryo it is divided by a constriction in its middle part into two portions, the more anterior giving rise to the two branchial trunks, the more posterior to the visceral trunk.

As in all the other urodeles hitherto studied, all the root fibers from the lateralis ganglia of IX and X unite into one large common root before entering the medulla. The area of entry of this root is the most anterior of all the roots of IX and X, being slightly farther cephalad than the visceral root of IX.

The dorsal lateralis X ganglion lies dorsal to the visceral X ganglion.

The ventral lateralis X ganglion lies throughout its extent in close contact with the dorso-lateral surface of the visceral X ganglion. In the 11.5 mm. stage it is partially fused with the ventral border of the dorsal lateralis X ganglion; later it becomes fused with dorsal lateralis IX also. No separate root of this ganglion could be identified.

The greater bulk of the ventral lateralis X ganglion is in the region of the branchial trunks, and it has here the appearance of contributing fibers to these trunks. Whether this is actually the case could not be definitely settled; our knowledge of the character of the branchial trunks in late larval stages

of Ambystoma and other forms would not lead us to expect to find lateralis fibers in them in the embryo. The character of this anterior portion of the ganglion is not considered definitely settled.

Except in the earliest embryonic stages, the nuclei of the cells of the lateralis ganglia are uniformly larger, rounder, and lighter-staining (with Delafield's hæmatoxylin) than those in the other ganglia. The differences between the nuclei of cutaneous and visceral ganglia are slight and not constant.

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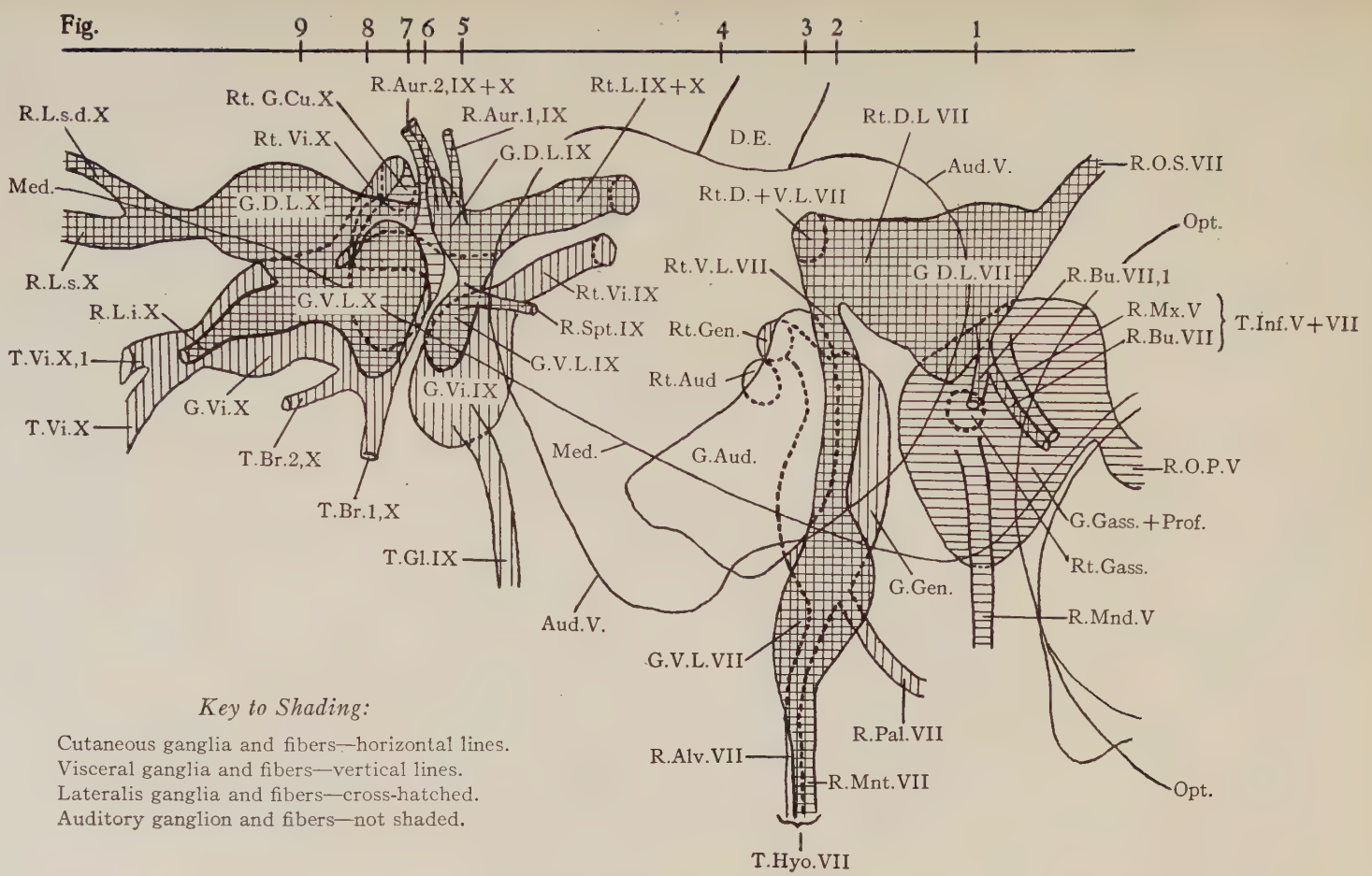
PLATE I.

A reconstruction of the cranial ganglia of an 11.5 mm. embryo of Ambystoma jeffersonianum, being a projection of these ganglia (from the right side of the head) upon the median, vertical plane of the head. The roots of the ganglia and the proximal portions of the chief nerves are shown, but motor components are omitted. The auditory vesicle, part of the optic vesicle, and the base of the brain are shown in outline. The areas of entry of the sensory roots into the medulla are indicated. Above the reconstruction are shown the positions of the sections figured in the following plates. Magnification, × 150.

ABBREVIATIONS.

Aud. V.—outline of auditory vesicle.
B. V.—blood vessel.
D. E.—ductus endolymphaticus.
En.—outgrowth of endoderm from lateral angle of pharynx.
G. Aud.—auditory ganglion.
G. Cu. X—cutaneous X ganglion.
G. D. L. VII—dorsal lateralis VII ganglion.
G. D. L. IX—dorsal lateralis IX ganglion.
G. D. L. X—dorsal lateralis X ganglion.
G. Gass. (+*Prof.*)—Gasserian ganglion, into which profundus ganglion has been incorporated.
G. Gen.—geniculate ganglion.
G. Vi. IX—visceral IX ganglion.
G. Vi. X—visceral X ganglion.
G. V. L. VII—ventral lateralis VII ganglion.
G. V. L. IX—ventral lateralis IX ganglion.
G. V. L. X—ventral lateralis X ganglion.
H. C.—horizontal canal of auditory vesicle.
M.—muscle.
M. d. m.—depressor mandibulæ muscle.
Med.—medulla; in reconstruction, base of medulla.
M. l. d.—longissimus dorsi muscle.
M. l. d. i.—longissimus dorsi inferior muscle.
M. ma.—masseter muscle.
Mo. VII—motor component of VII.
M. tem.—temporalis muscle.
No.—notochord.
Opt.—outline of optic vesicle.
Pal. B.—palatoquadrate bar.
Par.—parachordal.
Phar.—pharynx.
R. Alv. VII—ramus alveolaris VII.
R. Aur. 1, IX—ramus auricularis 1, IX.
R. Aur. 2, IX+X—ramus auricularis 2, IX+X.
R. Aur.?—branch of auricularis?
R. Bu. VII—ramus buccalis VII.
R. Bu. VII, 1—first branch of ramus buccalis VII.
R. L. i. X—ramus lateralis inferior X.
R. L. s. X—ramus lateralis superior X.
R. L. s. d. X—dorsal branch of ramus lateralis superior X.
R. Mnd. V—ramus mandibularis V.
R. Mnt. VII—ramus mentalis VII.
R. Mnt. VII, 1—first branch of ramus mentalis VII.
R. Mx. V—ramus maxillaris V.
R. O. S. VII—ramus ophthalmicus superficialis VII.
R. O. P. V—ramus ophthalmicus pro. fundus V.
R. Pal. VII—ramus palatinus VII.
R. Sac. VIII—ramus acusticus sacculi.
R. Spt. IX—ramus supratemporalis IX.
R. Utr. VIII—ramus acusticus utriculi.
Rt. Aud.—root of auditory ganglion.
Rt. Cu. X—root of cutaneous X ganglion.
Rt. D. L. VII—root of dorsal lateralis VII ganglion.
Rt. D.+V. L. VII—root of dorsal and ventral lateralis ganglia of VII.
Rt. Gass.—root of Gasserian ganglion.
Rt. G. Cu. X—cutaneous X root and ganglion.
Rt. Gen.—root of geniculate ganglion.
Rt. L. IX+X—lateralis root of IX and X.
Rt. L. X—lateralis root of X.
Rt. Mo. X—motor root of X.
Rt. Vi. IX—root of visceral IX ganglion.
Rt. Vi. X—root of visceral X ganglion.
Rt. V. L. VII—root of ventral lateralis VII ganglion.
T. Br. 1, X—truncus branchialis 1, X.
T. Br. 2, X—truncus branchialis 2, X.
T. Gl. IX—truncus glossopharyngeus IX.
T. Hyo. VII—truncus hyomandibularis VII.
T. Inf. V+VII—truncus infra-orbitalis V+VII.
T. Vi. X—truncus visceralis X.
T. Vi. X, 1—first branch of truncus visceralis X.



Key to Shading:

Cutaneous ganglia and fibers—horizontal lines.
Visceral ganglia and fibers—vertical lines.
Lateralis ganglia and fibers—cross-hatched.
Auditory ganglion and fibers—not shaded.

PLATE II.

(Shading as in Plate I; in addition, motor components in solid black.)

Fig. 1. A camera outline drawing of a portion of a section through the head of an 11.5 mm. embryo of Ambystoma jeffersonianum. The section passes through the dorsal lateralis VII ganglion (*G. D. L. VII*) and the Gasserian ganglion (*G. Gass.*). The position of this section in relation to the reconstruction on Plate I is indicated at the top of that plate. Magnification, × 80. The details of the area blocked out are shown in Plate IV, Fig. 1a.

Fig. 2. A camera outline drawing of a portion of a section through the head of the same 11.5 mm. embryo. The section passes through the geniculate (*G. Gen.*) and ventral lateralis VII (*G. V. L. VII*) ganglia. The junction of the roots of the dorsal and ventral lateralis VII ganglia is shown. The position of this section in relation to the reconstruction on Plate I is indicated at the top of that plate. Magnification, × 80. The details of the area blocked out are shown in Plate IV, Fig. 2a.

Fig. 3. A camera outline drawing of a portion of a section through the head of the same 11.5 mm. embryo. The section passes through the geniculate (*G. Gen.*), auditory (*G. Aud.*), and ventral lateralis VII (*G. V. L. VII*) ganglia. The position of this section in relation to the reconstruction on Plate I is indicated at the top of that plate. Magnification, × 80. The details of the area blocked out are shown in Plate IV, Fig. 3a.

Fig. 4. A camera outline drawing of a portion of a section through the head of the same 11.5 mm. embryo. The section passes through the posterior part of the auditory ganglion (*G. Aud.*). The position of the section in relation to the reconstruction on Plate I is indicated at the top of that plate. Magnification, × 80. The details of the area blocked out are shown in Plate IV, Fig. 4a.

Fig. 1.

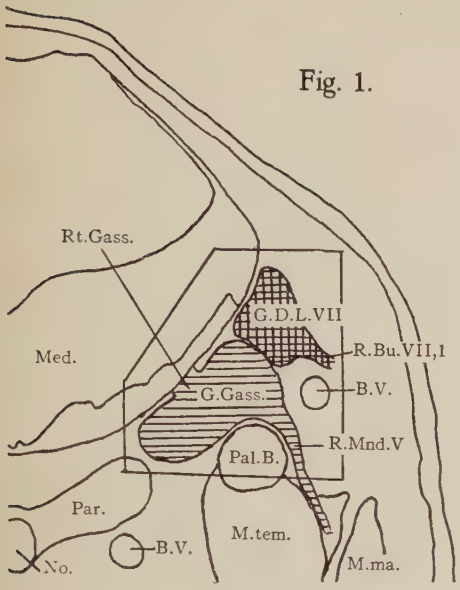


Fig. 2.

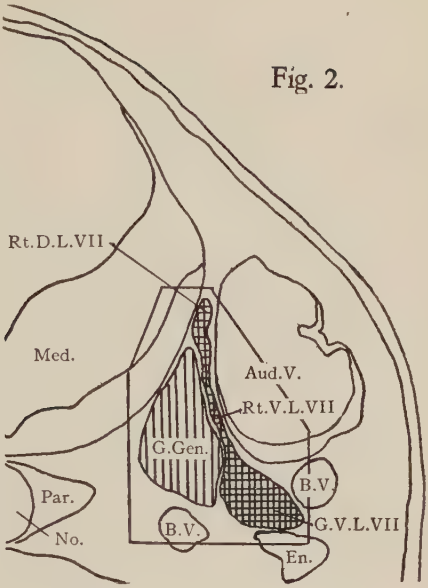


Fig. 3.

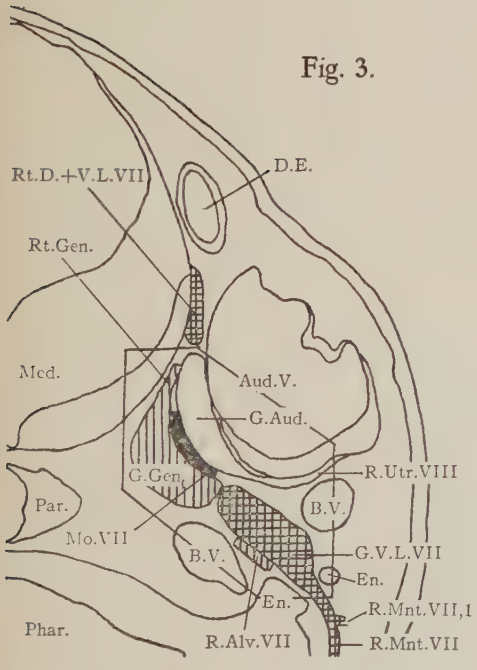


Fig. 4.

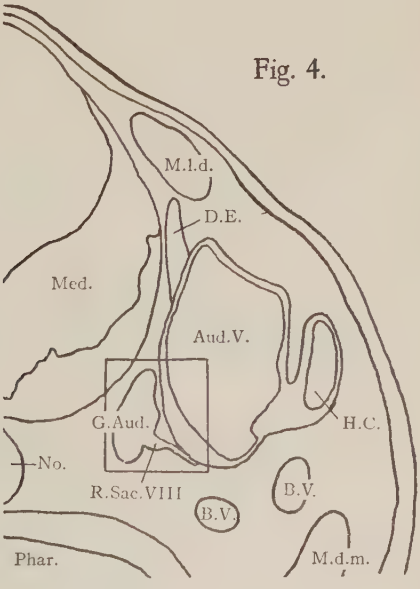


PLATE III.

(Shading as in Plate I; in addition, motor components in solid black.)

Fig. 5. A camera outline drawing of a portion of a section through the head of the same 11.5 mm. embryo of Ambystoma jeffersonianum. The section passes through the ventral lateralis IX ganglion (*G. V. L. IX*) and the visceral IX ganglion (*G. Vi. IX*). The position of the section in relation to the reconstruction on Plate I is indicated at the top of that plate. Magnification, × 80. The details of the area blocked out are shown in Plate IV, Fig. 5a.

Fig. 6. A camera outline drawing of a portion of a section through the head of an embryo of Ambystoma jeffersonianum, slightly older than the 11.5 mm. stage from which all the remaining drawings and the reconstruction were made. The section passes through both dorsal and ventral lateralis IX ganglia (*G. D. L. IX; G. V. L. IX);* through the visceral IX ganglion (*G. Vi. IX*); the cutaneous X ganglion (*G. Cu. X);* and through the root of the dorsal lateralis X ganglion (*Rt. L. X*). The position of the corresponding section of the 11.5 mm. embryo in relation to the reconstruction on Plate I is indicated at the top of that plate. Magnification, × 80. The details of the area blocked out are shown in Plate IV, Fig. 6a. (The relationship of lateralis and cutaneous components of the ramus auricularis could not be well shown in any one section of the 11.5 mm. embryo from which all the remaining drawings were made.)

Fig. 7. A camera outline drawing of a portion of a section through the head of the same 11.5 mm. embryo of Ambystoma jeffersonianum used in making all drawings except Figs. 6 and 6a. The section passes through the cutaneous X ganglion (*G. Cu. X*); the root of the dorsal lateralis X ganglion (*Rt. L. X*); the ventral lateralis X ganglion (*G. V. L. X*); the visceral X ganglion (*G. Vi. X*); and the visceral IX ganglion (*G. Vi. IX*). The position of the section in relation to the reconstruction on Plate I is indicated at the top of that plate. Magnification, × 80. The details of the area blocked out are shown in Plate IV, Fig. 7a.

Fig. 8. A camera outline drawing of a portion of a section through the head of the same 11.5 mm. embryo. The section passes through the cutaneous X ganglion (*G. Cu. X*); the ventral lateralis X ganglion (*G. V. L. X*); and the visceral X ganglion (*G. Vi. X*); also through the anterior tip of the dorsal lateralis X ganglion (*G. D. L. X*). The position of the section in relation to the reconstruction on Plate I is indicated at the top of that plate. Magnification, × 80. The details of the area blocked out are shown in Plate IV, Fig. 8a.

Fig. 9. A camera outline drawing of a portion of a section through the head of the same 11.5 mm. embryo. The section passes through the visceral X ganglion (*G. Vi. X*) and the fused dorsal and ventral lateralis X ganglia (*G. D. L. X* and *G. V. L. X*). The position of the section in relation to the reconstruction on Plate I is indicated at the top of that plate. Magnification, × 80. The details of the area blocked out are shown in Plate IV, Fig. 9a.

Fig. 5.

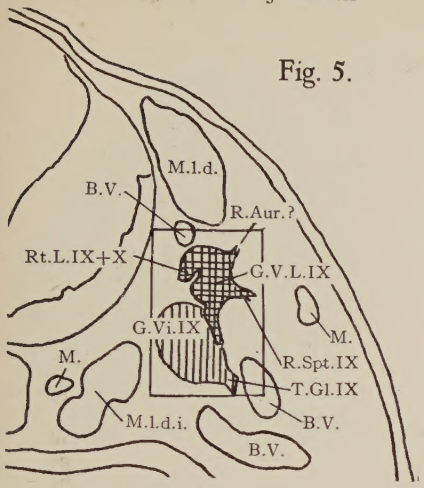


Fig. 6.

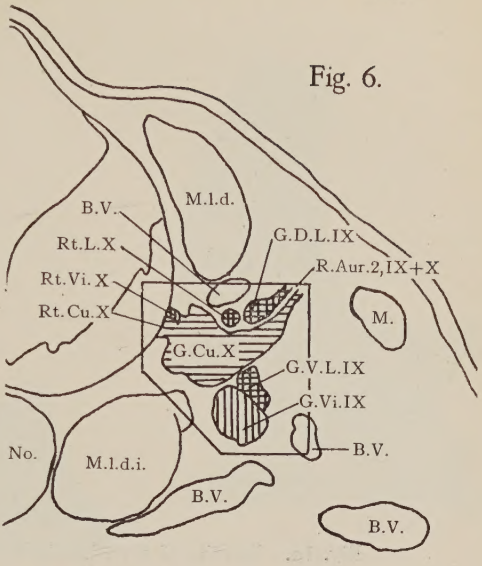


Fig. 7.

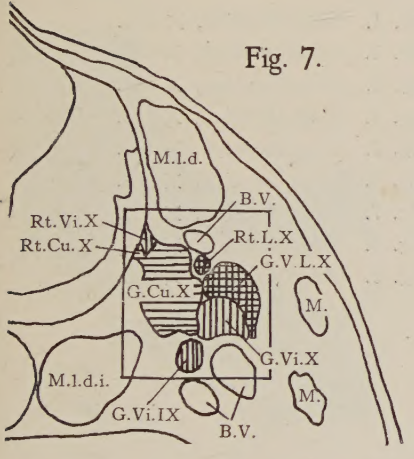


Fig. 8.

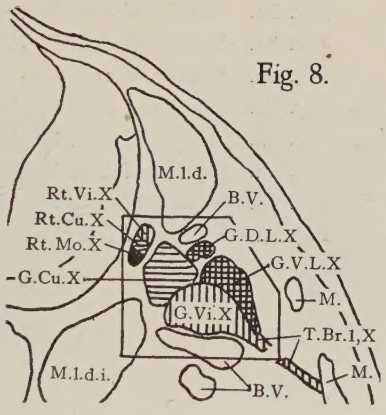


Fig. 9.

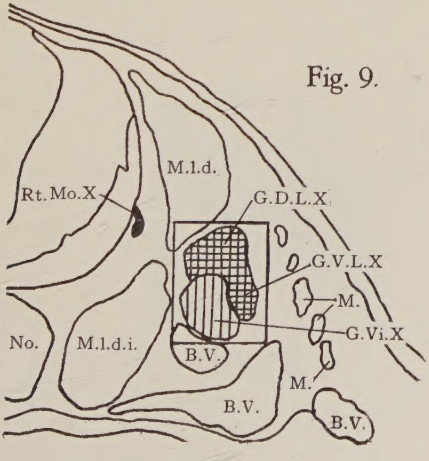


PLATE IV.

Fig. 1a. Details of area blocked out in Fig. 1. Magnification, × 132.
Fig. 2a. Details of area blocked out in Fig. 2. Magnification, × 132.
Fig. 3a. Details of area blocked out in Fig. 3. Magnification, × 132.
Fig. 4a. Details of area blocked out in Fig. 4. Magnification, × 132.
Fig. 5a. Details of area blocked out in Fig. 5. Magnification, × 132.
Fig. 6a. Details of area blocked out in Fig. 6. Magnification, × 132.
Fig. 7a. Details of area blocked out in Fig. 7. Magnification, × 132.
Fig. 8a. Details of area blocked out in Fig. 8. Magnification, × 132.
Fig. 9a. Details of area blocked out in Fig. 9. Magnification, × 132.

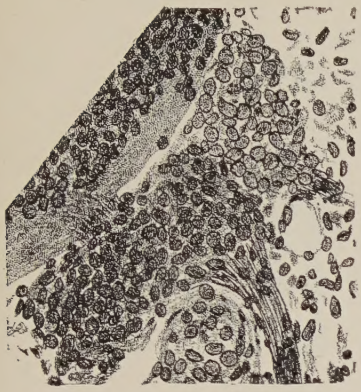


Fig. 1a.

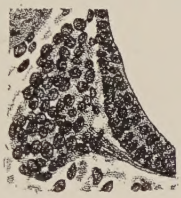


Fig. 4a.

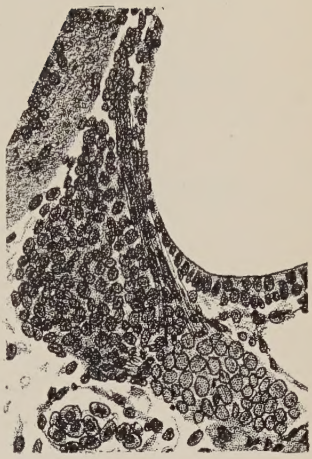


Fig. 2a.

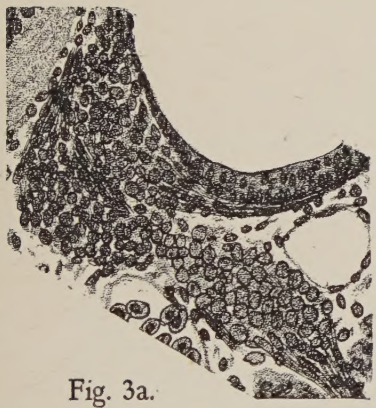


Fig. 3a.

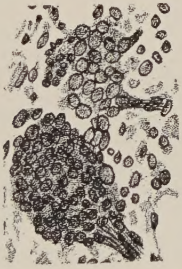


Fig. 5a.

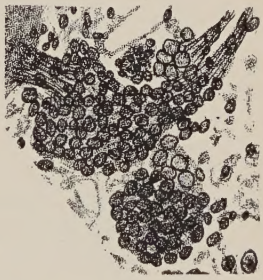


Fig. 6a.

Fig. 7a.

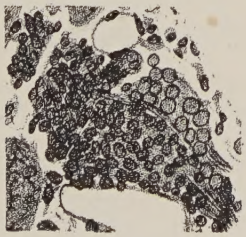


Fig. 8a.

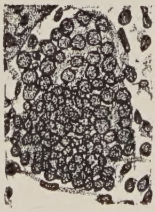


Fig. 9a.